TRIAXIAL SHEAR EXPERIMENTS ON A GRAVEL CONTAINING PORTLAND CEMENT AND LIME-FLY ASH ADMIXTURES

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TRIAXIAL SHEAR EXPERIMENTS ON A GRAVEL CONTAINING PORTLAND CEMENT AND LIME-FLY ASH ADMIXTURES

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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ABSTRACT

The effects upon the triaxial shear strength of a local submarginal gravel, brought about by adding several different percentages of Portland cement and lime-fly ash admixtures were investigated. The vacuum triaxial testing program carried out to investigate these effects was of a specialized nature in that the maximum particle size included in the test specimens was 3 inches. This resulted in the testing of specimens 12 inches in diameter by 24 inches high. In comparison to the triaxial tests performed on the native gravel, it was found that the presence of the various admixtures investigated:

(a) improved the workability of the gravel, especially the lime-fly ash admixtures,

(b) increased the dry density of the compacted specimens, depending on type and quantity of admixture,

(c) decreased the Plasticity Index of the fine fraction of the gravel,

(d) substantially increased the compressive strength of the material. In degree of improvement, the Portland cement admixture investigated proved superior to the lime-fly ash admixture on an equal material cost basis.

Not included within the scope of this investigation were the effects upon the strength and plasticity of the admixture-aggregate compositions resulting from extended periods of cure coupled with the cyclic action of weathering agencies, as well as the effects upon strength as a result of saturating the specimens before test.

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CHAPTER I

PURPOSE AND PREVIEW OF INVESTIGATION

The chief purpose of this investigation was to ascertain the nature and degree of compressive strength benefits resulting from the treatment of a local gravel with Portland cement and lime-fly ash admixtures. The gravel from this particular deposit is typical of many submarginal gravels found in Alberta in that it contains a relatively high proportion of plastic fines. The amount of these fines present and their plasticity characteristics are higher than the usual limits set for subbase, base and surface courses by most North American highway agencies. For a typical set of such specifications, see Appendix A.

It was hoped that chemical stabilizing agents could be found that would economically increase the strength characteristics of this material so that it might be usefully employed in subbase and base course construction when better sources of gravel become depleted or become too far distant for economic use. After a survey of some of the work done in this field and reported in the literature on the subject, it was decided that Portland cement and lime-fly ash would be investigated as possible admixtures as they have both been used successfully on gravels of this type elsewhere. (See page 133, biographical source 11 and biographical source 18.) The cement, lime, and fly ash are all available in quantity locally and are relatively cheap, especially the fly ash which is a waste product of coal-burning utility plants.

Previous investigators have used several different methods of evaluating strength changes as criteria in comparing the effects of admixtures. Among these methods are the triaxial shear test, the California bearing ratio test, [2,3,5,6] and the Hveem cohesiometer test [4]. The usual type of triaxial shear test employed was an unconfined test of cubes or small cylinders [1,7,8,9,10]

rather than restrained tests [5,6]. These tests were usually done on minus #4 sieve size material.

It was considered desirable for this investigation however, that the whole range of gravel sizes which might be used in a subbase or base course be included in the strength tests so that the effects of the coarser sizes would be included. A material simulating a minus 3 in. crush was used for the investigation and it was concluded that the presence of this size of rock in a test specimen would invalidate any semi-empirical, penetration type, strength tests (C.B.R.). Thus the triaxial shear test was decided upon for use in the investigation. Since unconfined strength testing (triaxial shear testing with zero lateral pressure) could not be satisfactorily carried out on this granular material, vacuum triaxial shear tests at three different lateral pressures was the method chosen to investigate strength changes. This method, though not as readily carried out as unconfined tests, does give more information and is a great deal more simple to execute than positive pressure triaxial tests. Moreover, the vacuum triaxial test is well suited for use in tests on unsaturated granular material [14,16], such as that used in this investigation. To test this gravel triaxially meant that a specimen at least 12 ins. in diameter by 24 ins. in length would be required, as it has been found that a minimum ratio of test specimen diameter to maximum particle size of 4 should be observed [14]. Similarly, a ratio of height to diameter of 2 is usually employed in cylindrical compression testing. Special apparatus to accommodate the preparation and testing of specimens of this size by vacuum triaxial methods was designed and constructed.

A comprehensive series of classification and identification tests were carried out upon the materials to be used in the investigation before commencing

with the triaxial testing program.

The physical labor which is involved in processing, mixing and compacting triaxial specimens of these dimensions is considerable as well as being time consuming. For these reasons, the scope of the triaxial shear investigation was limited to:

(a) one particular type of gravel,

(b) two different percentages of a particular cement tested after a specific period, i.e. one day cure,

(c) two different percentages of one particular lime and one particular fly ash (the percentages of lime to fly ash by weight remaining constant), tested after two periods of cure, i.e. no cure and one week cure.

While not included within the scope of this investigation, the following considerations might well prove worthy of future study:

(a) the effects of long-term cyclic weathering action upon the permanency of the strength and plasticity benefits derived by the use of the admixtures investigated,

(b) the immediate and long-term effects upon the plasticity characteristics of the gravel resulting from incorporation of trace quantities of the admixtures investigated,

(c) the effects upon the strength of the admixture-aggregate compositions when tested in a saturated condition rather than a partially saturated condition.

The maximum amount of cement which was considered to be economical for use with this gravel was 5% by weight of dry aggregate. Using this figure, the cost of Normal Portland cement used in a 6 in. compacted base would range from $ .25 to $ .28 per sq.yd. ($1.50 to $1.68 per cu.yd. compacted) for a density range in the compacted material of 125 to 140 lbs. per cu.ft. The amount of lime-fly ash which could be used as an admixture at comparable material cost was found to be 3.5% lime and 7% fly ash by weight of aggregate. The 2 : 1

ratio of fly ash to lime was decided upon from consideration of work done elsewhere [1]. A second test series using reduced amounts of cement and lime-fly ash was used to attempt to obtain some picture of the effect on strength of the amounts of admixture used.

Lime-fly ash rather than lime was investigated because previous authors [6, 11] have reported that sandy soils are not too responsive to treatment with lime alone. The fact that fly ash also brings about a pozzolanic action with lime was thought to be a worthwhile reason for using it even though the extent of this pozzolanic action would not be too apparent after the necessarily short curing periods used in the investigation.

Pulverized quicklime was chosen for use rather than a hydrated lime product because there is nearly 25% more active calcium oxide in the quicklime. Bulk quicklime is also slightly cheaper than bagged hydrate on a unit weight basis. These savings brought about by the use of quicklime are offset slightly by the fact that the handling costs of quicklime are higher than for hydrated lime because of the precautions taken in handling it.

In an attempt to obtain close control over the uniformity of grading of the gravel in each specimen tested, so that strength results would be comparable, the native gravel was split into five size ranges and then recombined in the desired percentages to make up 200-pound batches ready for the preparation of the test specimen.

The usual curing period of Normal Portland cement stabilized specimens is seven days, but because of the lack of sufficient 12 in. diameter by 24 in. molds and to achieve the necessary economies in time, the curing period

was reduced to 24 hours. However, High Early Strength Portland cement was employed rather than Normal Portland as it was felt that the one-day strength of material treated with this type of cement would be close to, but slightly less than, the seven-day strength of the same material treated with a Normal Portland cement conforming to the A.S.T.M. specifications.

In all, thirty-two triaxial tests were performed and over 6,000 lbs. of processed gravel were required for the investigation.

CHAPTER II

CLASSIFICATION, IDENTIFICATION AND ANALYSES OF MATERIALS INVESTIGATED

Gravel The source of the gravel used in the investigation was the Crawford Pit (SW 33-36-20-4) near Stettler, Alberta. From visual examination the material could be described as a "dirty gravel" and gradation and plasticity tests show that the material corresponds to the GF soil group of the Casagrande Airfield Classification System [12].

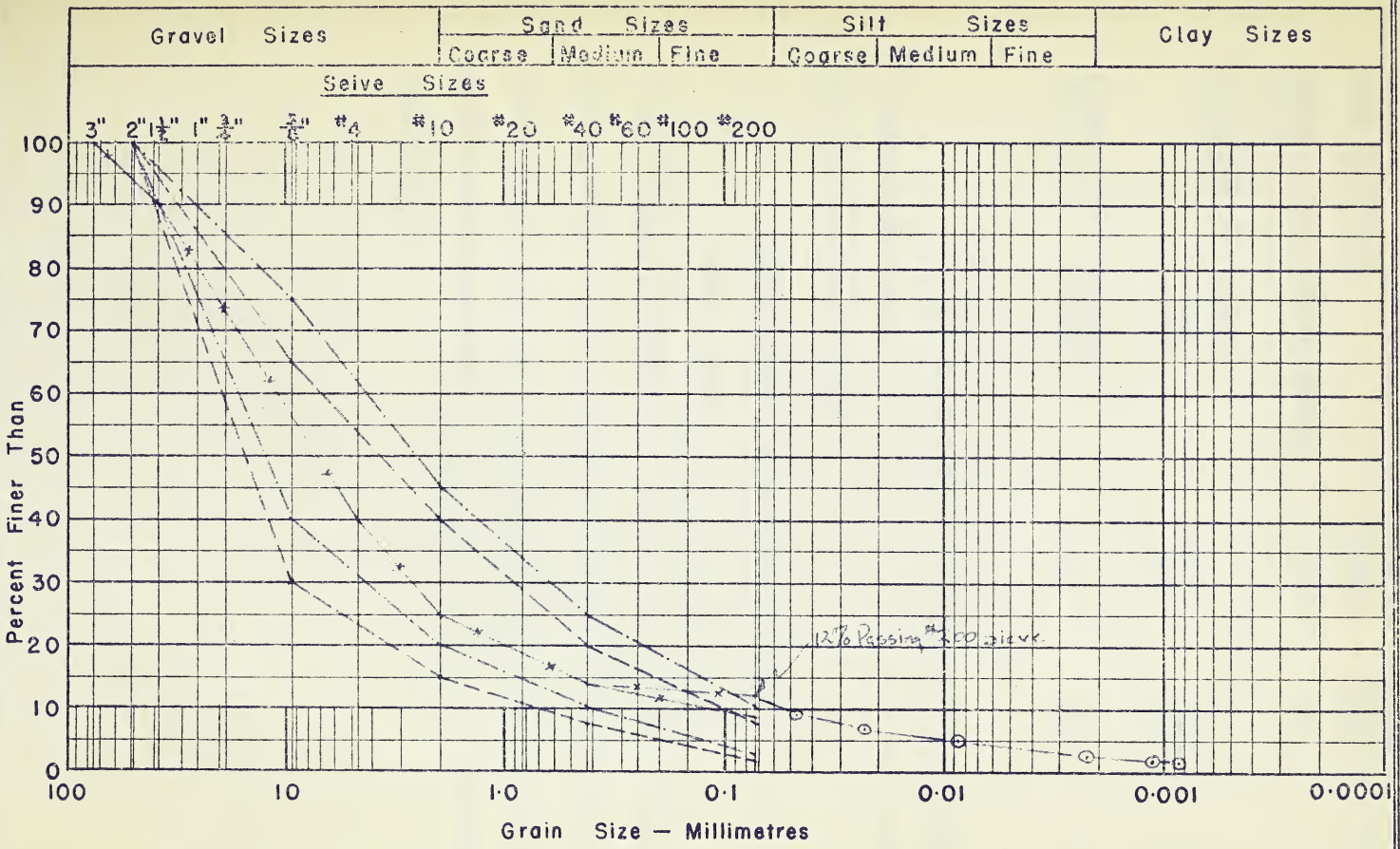
Table 1 shows the results of the sieve and plasticity tests performed on samples taken throughout the pit area. Figure 1 shows the average gradation of the material tested and the grading curve followed in the investigations as well as the applicable limits of the American Association of State Highway Officials grading specifications.

Table 11 shows the effects of the admixtures on the plasticity characteristics of the Crawford fines used in the strength investigations. In all the plasticity tests shown, the fines were allowed to soak 24 hours at a moisture content near the plastic limit. The figures 3, 7 and 24 hours shown in the Table indicate additional soaking time after the additive was mixed with the fines.

The sieve and hydrometer data sheets and the Atterberg limit data sheets which form the basis for Table 1, Figure 1, and Table 11 are contained in Appendix A. Excerpts from the A.A.S.H.O. specifications are also given in that section.

TABLE 1 MECHANICAL ANALYSES AND PLASTICITY TESTS - CRAWFORD GRAVEL PIT

Sample No.	Oversize	% Passing Designated Sieve 3"	1-1/2"	3/4"	#4	#10	#40	#200	Atterberg Limits Liquid Limit	Plastic Limit	Plasticity Index
21194	10	100	91	69	31	17	9.9	6.3	34.5	18.0	16.5
21195	-	100	85	65	35	21	11	6.7	35.1	23.8	11.3
21196	4	100	94	83	53	29	12	7.8	38.7	19.5	19.2
21197	-	100	96	82	39	24	14	9.0	38.0	19.1	18.9
21198	2	100	93	83	56	36	17	12.0	44.9	23.0	21.9
21199	11	100	89	72	36	23	15	9.3	31.2	17.3	13.9
21200	-	100	93	80	43	33	24	11.0	24.8	15.4	9.4
21201	7	100	90	72	37	18	9.7	6.4	39.1	21.6	17.5
21202	8	100	82	63	32	20	12	7.8	38.3	22.6	15.7
21203	3	100	93	74	41	27	16	11.0	40.3	20.9	19.4
21473	8	100	86	67	37	25	15	9.5	32.8	16.7	16.1
21475	14	100	88	69	39	28	17	10.2	32.2	16.7	15.5
Average	6	100	90	73	40	25	14	8.9	35.8	19.5	16.3



UNIVERSITY of ALBERTA
DEPT. of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY

GRAIN SIZE CURVE

PROJECT
SITE
SAMPLE CRAWFORD PIT - K.M.
LOCATION SW 32 - 36 - 20 - 4
HOLE DEPTH
TECHNICIAN DATE MAY 14/58

FIG. 1

FIG. 1 GRAIN SIZE CURVES

TABLE 11 EFFECT OF ADMIXTURES UPON PLASTICITY OF CRAWFORD GRAVEL FINES

Material Tested	Liquid Limit	Plastic Limit	Plasticity Index
Minus #40 sieve sized material (fines)	40.5	23.5	17.0
Fines +5% H.E. cement ... 3 hr.	41.6	32.5	9.1
... 7 hr.	41.7	34.9	6.8
Fines + 3.5% quicklime and 7% fly ash ... 24 hr.	37.4	33.5	3.9

The specific gravities of the coarse and fine fractions of the Crawford gravel used in the triaxial shear experiments were as follows: (see Appendix A for test data)

Specific gravity of + #4 material = 2.67

Specific gravity of - #4 material = 2.69

In the combination of 60% coarse, 40% fine, the average specific gravity of the mixture would be 2.68. The data for the foregoing tests are shown in Appendix B and the results were used in plotting zero air voids curves in the compaction tests as well as in computing approximate figures for the degree of saturation in the triaxial tests.

TABLE 111 RESULTS OF COMPACTION TESTS ON CRAWFORD MINUS #4 SIEVE MATERIAL

Material Tested	Test Type	Optimum Moisture Content	Maximum Dry Density
Crawford -#4 material	Modified Proctor	9.0 %	131.7 lbs./cu.ft.
Crawford -#4 material with 5% H.E. cement by weight of aggregate	Modified Proctor	8.8	133.4
"	1/2 Standard Proctor (3 lifts, 12-13-13 blows)	12.0	117.5
Crawford -#4 material with 3.5% quicklime and 7.0% fly ash by weight of aggregate	1/2 Standard Proctor (3 lifts, 12-13-13 blows)	15.8	109.3

The results of the compaction test series which were run are shown in Table 111. Modified Proctor and one-half Standard Proctor tests were performed using the various admixtures (data sheets in Appendix A) and the desired molding water contents of the triaxial specimens were based upon the optimum moisture contents obtained in the two tests. The figures arrived at for the desired molding moisture contents of the triaxial specimens are thus nothing more than "guesstimates" of the true optimums because although the same compactive effort per unit of compacted volume was employed in preparing the triaxial specimens as would be employed in one-half Standard Proctor tests, the ratio of specimen diameter to specimen height was different, the ratio of specimen diameter to maximum particle size was different, the compaction hammers were different, i.e.

	Std. Proctor Hammer	Hammer used to compact triaxial specimens
Weight	5.5 lbs.	10 lbs.
Fall	1.0 ft.	2.5 ft.
Diameter of face	2"	3-7/8 ins.

and the compaction technique employed was different in that for a Proctor test a constant number of blows is given to each layer but for the compacted triaxial specimens the number of blows increased with each layer from 44 to 68 in an effort to get uniform densities in the seven layers used.

In spite of these differences, it was felt that the approximate method used for determining the molding water content for the triaxial specimens was adequate for the purposes of the investigation, i.e. not to find absolute values of maximum strength, but to compare strengths under equal conditions other than admixture.

Appendix A contains sample calculations pertaining to the estimate of desired molding water content for the triaxial specimens for one of the test series carried out.

Cement The High Early Strength Portland Cement used in the investigation was a local product and the chemical and physical analyses of a representative sample of the material as performed by the producer are shown in Table IV.

TABLE IV RESULTS OF PHYSICAL AND CHEMICAL TESTS ON THE CEMENT USED IN THE INVESTIGATION

Physical Tests		Results	(Specifications (A.S.T.M. C150-55 Type III)
Fineness (Blaine)		4478 cm^2/gm	--
Normal Consistency		28.2 %	
Setting time			
	initial	$2^h\ 50^m$	not less than 45^m
	final	$5^h\ 10^m$	nor more than 10^h
Compressive Strength			
	1 day	2175 psi	1700
	3 days	4325	3000
	7 days	5900	--
Chemical Composition			
	SiO_2	21.09 %	--
	Al_2O_3	5.10	--
	Fe_2O_3	2.84	--
	CaO	63.93	--
	MgO	2.88	5 Max
	SO_3	2.28	3 Max
	Ignition Loss	1.66	3 Max
	Insoluble	0.42	0.75 Max
	Free Lime	0.87	--
Tricalcium Aluminate			
	$3CaO.Al_2O_3$	8.7	15 Max

Lime The lime used in conjunction with fly ash for the strength investigations was a pulverized quicklime having the physical and chemical properties shown in Table V. These test results were supplied by the producer.

TABLE V RESULTS OF PHYSICAL AND CHEMICAL TESTS ON THE LIME USED IN THE INVESTIGATION

Physical	Results	Stabilization Specifications (as suggested by National Lime Ass.)
Fineness		
Passing 100 sieve	95%	85%
Passing 200 sieve	82%	
Chemical		
Calcium oxide	95.75 %	75% min. oxide content
Magnesium oxide	1.50	as calcium or calcium-magnesium oxide.
Iron & Aluminum oxide	0.38	--
Ignition loss	1.65	
Insoluble	0.50	

The relative effectiveness of a lime in stabilizing a material varies with the oxide content capable of reacting with the soil material and hence the lime requirement for quicklime stabilization is lower than for stabilization with a hydrated lime because of the high percentage of calcium oxide contained in quicklime.

Fly Ash The fly ash used in the lime-fly ash investigations has the physical and chemical properties shown in Table VI. The results shown were obtained from the chief user of this particular fly ash.

TABLE VI RESULTS OF PHYSICAL AND CHEMICAL TESTS ON THE FLY ASH USED IN THE INVESTIGATION

Physical	Results
Specific gravity	1.91
Fineness	
Passing 50 sieve	86%
Chemical	
Silicates	56.93
Iron and Aluminum oxides	27.54
Calcium oxide	7.06
Magnesium oxide	2.04
Sulphur trioxide	0.62
Ignition loss	2.44
Undetermined	3.37

CHAPTER III

APPARATUS AND PROCEDURES FOR TRIAXIAL TESTS

Apparatus Shown on Plates I, II and III in Appendix B are the detailed plans for the special equipment constructed for use in the vacuum triaxial testing of 12 in. diameter by 24 in. high specimens. Included at the close of Chapter III are pictures of the equipment and some phases of the triaxial tests carried out.

The following is a list of equipment used in conjunction with the vacuum triaxial testing program.

(1) A Fairbanks Morse 4,000 lb. capacity mechanical compression testing machine was used for vacuum triaxial tests 1 to 9.

(2) A Tinius Olsen 30,000 Kgm. capacity hydraulic compression testing machine was used for tests 10 to 32. Special extensions for the uprights were required to accommodate the height of the test specimens.

(3) A stable steel compaction table of approximately the same height as the bed of the Tinius Olsen machine facilitated the movement of the compacted test specimen (approximate weight, 275 lbs.) into the Tinius Olsen machine for test.

(4) A vacuum source including a reservoir and a supply of air lines with quick coupling connectors. The vacuum source used was a single stage vacuum pump capable of exhausting nearly a full atmosphere.

(5) A mixer of 3-1/2 cu.ft. capacity was employed. This mixer was

of the tilting drum, end discharge type and rotated at 24 revolutions per minute. Mixing was done in all cases at a tilt as severe (flat) as possible without discharge of material during mixing.

(6) The triaxial specimen molding and testing equipment, i.e. rubber lined split mold, top plate, bottom plate, compaction guide sleeve, compaction hammer (Marshall hammer with 12 ins. added to fall), 1,000-lb. capacity weigh scale, 100-lb. capacity scale, rectangular metal box large enough to transport mixed sample, rubber strips for attaching membrane to plates, strain dial of 1 in. travel in 0.001 in. increments, and a 20 Kg. scale and pans for moisture content determinations.

Procedure The procedures followed in the various triaxial tests were as follows:

(1) In triaxial test #1 a compactive effort of 55 blows on each of 6 lifts delivered by a Modified Proctor hammer was employed. The dry density resulting from this compactive effort was deemed to be too low and the compactive effort in future tests was increased. The number of lifts was increased to 7 and the number of blows per lift increased to an average of 56 (44 on the first, 48 on the second, etc. and 68 on the seventh). The compaction hammer was also altered. Instead of 10 lbs. falling 18 in. on a 2 in. diameter face, the hammer was modified to 10 lbs. falling 30 ins. on a 3-7/8 in. diameter face. The larger face was employed because it was found that it did not degrade the gravel to the extent that the 2 in. diameter hammer face did.

(2) In triaxial tests #2 to #31 the following procedures were used:

(a) The native gravel was split into 5 size ranges (3 in. to 3/4 in., 3/4 in. to #4, #4 to #10, #10 to #40, and minus #40). A certain fraction of crushed

oversize was included in each size range but by far the largest number of crushed particles were in the 3 in. to 3/4 in. range. Over 6,000 lbs. of raw gravel were processed in this fashion to supply material for the test program.

(b) The 200-lb. batches of air dry gravel that were made up for triaxial specimen molding had the following composition (in accordance with desired grain size curve):

-3 in. + 3/4 in.	54 lbs.
-3/4 in. + #4	66 lbs.
-#4 + #10	30 lbs.
-#10 + #40	22 lbs.
-#40	28 lbs.
	200 lbs.

(c) The hygroscopic moisture content of a representative sample of the minus #4 sieve size material was obtained for aid in determining the quantity of water to be added at the mixer to arrive at the moisture content desired in the compacted specimen.

(d) The required weight of admixture and water were weighed out separately and the gravel and admixture introduced into the mixer.

(e) The mixer drum was lowered from the charge position to the mixing position and the mixer was started.

(f) The water was then added over a 10-second interval and the material was allowed to mix for a 3-minute period before discharging into a metal box.

(g) The sample was then remixed in the box by shovel and then the box and sample were weighed.

(h) Before the sample was mixed, the membrane was attached to the base plate. The mold was then placed carefully about both and tightened. The rubber membrane was then brought up and stretched over the top of the mold and a vacuum of 0.3 atmospheres applied between the membrane and the mold to effect a smooth, tight fit of the membrane to the interior of the rubber-lined mold. The mold now rested on the base plate which rested on the compaction table and all was in readiness for the start of compaction.

(i) The specimen was then compacted in the mold in seven equal layers. 44 blows were used on the first layer with the number increasing 4 per layer so that there were 68 blows used on the seventh layer. Seven was the maximum number of layers possible with 3 in. maximum sized particles in a 24 in. high specimen. The compaction hammer used was a Marshall Compaction Hammer with the fall increased from 18 to 30 inches. Before compacting the last layer, the guide sleeve was fitted onto the mold to allow initial compaction of the seventh layer and to prevent, as far as possible, damage to the membrane. After one-half of the blows were given to the seventh layer, the guide sleeve was removed so that close attention could be given to the last half of the blows so that the resultant surface was relatively flat and in otherwise good shape to receive the top plate.

(j) The top plate was lowered into position and the membrane was drawn up and over this plate. A rubber strip was used to tie it to the plate and a special groove cut into the plate assisted in this fastening process.

(k) The remainder of the sample and the box were weighed to determine the weight of moist material used in preparing the specimen.

(l) In the case of the triaxial tests on the native gravel (tests #1 to 8, 13, 14, 18) there was no curing period necessary so preparations for the triaxial test began immediately after molding. In one test series using 3.5% quicklime, 7% fly ash (tests #20, 21, 22) and in one test series using 2% quicklime and 4% fly ash (tests #24, 25, 26) no curing period was used in order to see what immediate effects the admixtures had on the strength of the composition. For the 5% H.E. cement test series (tests #9 to 12, 15 to 17, 19, 32) and also for the 2% H.E. cement series (tests #29, 30, 31) 24 hour curing periods were used. For three separate triaxial tests using the lime-fly ash admixtures (tests #23, 27, 28) curing periods of one week were used to get some idea of how great the pozzolanic strength had become in this short a period.

(m) When the specimen was ready to be tested, the desired vacuum (0.3, 0.6 or 0.9 atmospheres) was obtained in the reservoir with the vacuum pump and the leads from the reservoir were attached to the top and bottom plates. With the specimen evacuated to the desired negative pressure, the mold was stripped carefully from around the specimen. Leaks in the membrane were located and repaired with small patches of membrane rubber and special rubber cement.

(n) When the desired vacuum could be held constant on the specimen, the specimen was manoeuvered from the compaction table onto the bed of the

testing machine where it was centered.

(o) The strain dial was adjusted and the zero reading obtained. The length of the specimen was measured at 90 degree intervals and averaged. The hydraulic Tinius Olsen machine was turned on. The bed of the machine was "floated" and the machine zeroed at the range desired for testing. The self-leveling loading head was then brought into contact with the specimen and the test was started.

(p) The tests were of the constant stress type, in that it was attempted to load the specimens to failure in 20 minutes at a constant rate of stress. (5% of the total load would thus be applied each minute.) This could be accomplished with the mechanical testing machine but was much more difficult to manage with the hydraulic machine. Bibliographical source 14 points out that small changes in loading rates have no significant effect on results in triaxial tests on granular materials.

(q) The tests were continued until failure of the specimens. Failure was evidenced by increased sounds of distress from the specimen and a rapid increase in the rate of strain at the same or slightly reduced load. Slight bulging about the central portions of the specimen was all that could be seen after the specimen was removed from the machine and the membrane was peeled down. Failed samples stood erect without benefit of vacuum with no evidence of slumping.

(r) About 50 lbs. of moist material from each specimen was used for a moisture content determination of the tested material and the remainder of the specimen was discarded.

(s) This procedure was repeated for all tests with only one variation. In several tests the seventh layer was too low or too irregular for the proper placement of the top plate. In these few cases a cushion of fines was used to properly seat the plate. This weight of fines was included in the weight of specimen.

3. Triaxial test #32 was an unconfined test on a 5% High Early Strength cement and Crawford gravel composition. A membrane was employed but the specimen was tested without benefit of vacuum.

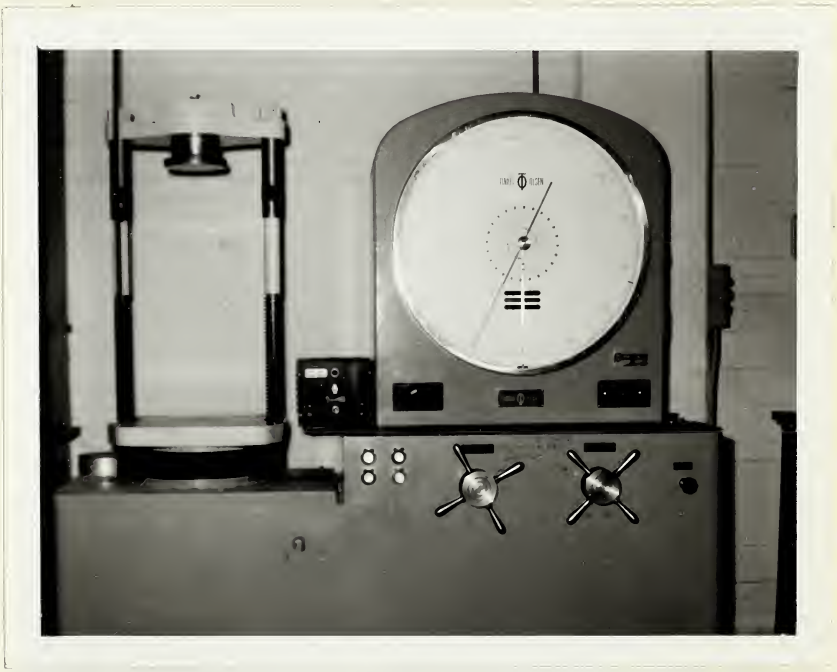


Photo 1. Tinius Olsen 30,000 Kgm. Capacity Hydraulic Compression Testing Machine

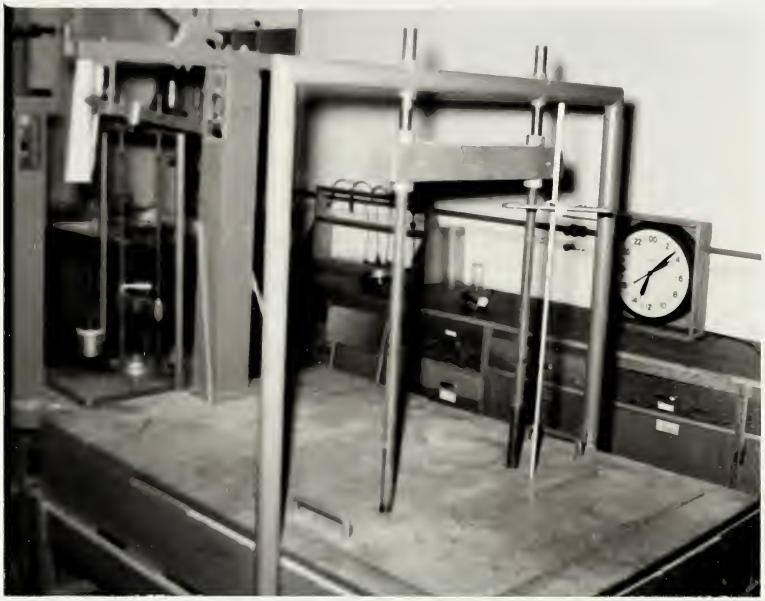


Photo 2. Fairbanks Morse 4000 lb. capacity Mechanical Compression Testing Machine

Photo 3. Tilting Drum Type Mixer, Sample Box and Weigh Scale

Photo 4. Rubber lined Split Mold With Top Plate (with handles) And Base Plate

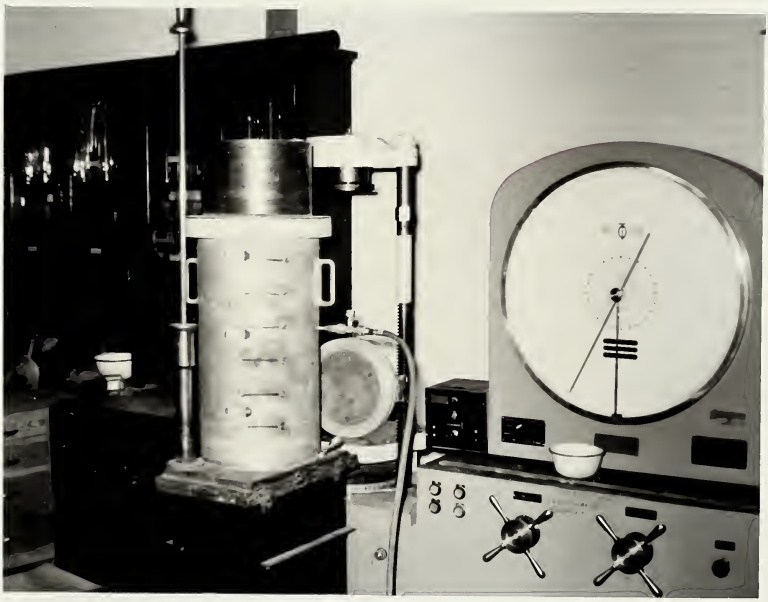


Photo 5. Specimen Compaction, Showing Table, Hammer and the Guide Sleeve

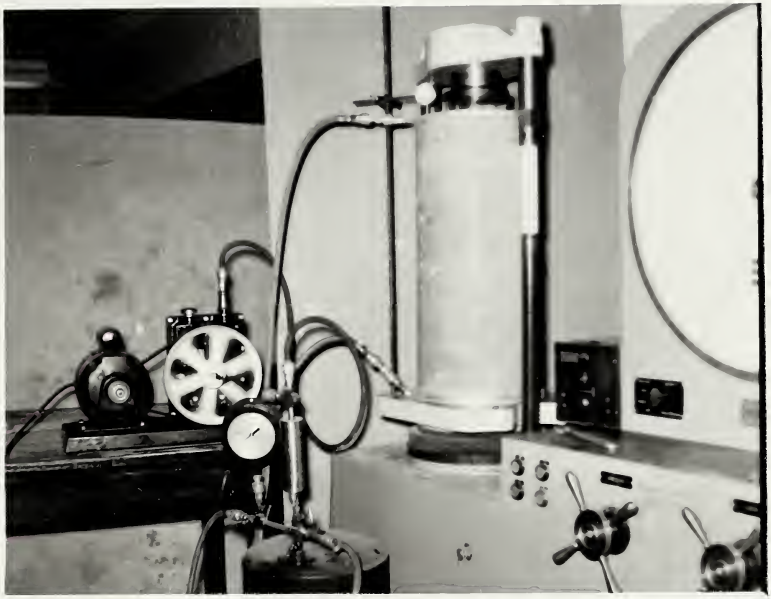


Photo 6. Specimen Ready For Triaxial Test

Photo 7. Failed Specimen With Vacuum Leads Removed And Membrane Peeled Down

CHAPTER IV

TRIAXIAL TESTING PROGRAM RESULTS

The results of all vacuum triaxial tests are shown in tabular form in the following tables (Tables VIIA, VIIB, VIIC) depending on admixture. The data sheets for all triaxial tests are included in Appendix B. The results of the test program, with the exception of test #1 which employed a different compaction technique, have been presented in other forms as well. Stress-strain characteristics of the various mixtures tested are compared with those of the native gravel in Figures 2A, 2B, 2C and 2D. A comparison of stress-strain characteristics of all compositions at one restraining pressure is shown in Figure 3. Mohr circles for some of the various triaxial tests at failure are shown in Figures 4A, 4B, 4C, and 4D, and a graphical summary of the rupture lines thus obtained for each test series is shown in Figure 5. A plot of deviator stress at failure versus test lateral restraining pressure (Figure 6) for the various test series is also shown. Figure 7 is a plasticity chart which shows the results of plasticity tests run on the Crawford gravel fines with and without admixtures. The data sheets for these plasticity tests are included in Appendix A.

TABLE VIIA RESULTS OF TRIAXIAL TESTS OF CRAWFORD GRAVEL (3 in. max. size)

Test Number	Moist Unit Wt. lbs./cu.ft.	Dry Unit Wt. lbs./cu.ft.	Moisture Content %	Lateral Pressure Kgm/sq.cm.	Deviator Stress at Failure Kgm/sq.cm.	Strain At Failure %
1	120.0	115.0	4.66	0.31	1.19	3.56
2	122.6	118.5	3.39	0.31	1.78	2.15
3	120.2	116.2	3.61	0.31	1.91	1.26
4	121.0	116.1	4.21	0.31	1.90	2.43
5	123.4	118.2	4.43	0.62	2.51	4.02
6	122.0	117.7	3.72	0.89	3.33	2.77
7	121.5	116.5	4.29	0.62	2.80	2.80
8	121.6	117.3	3.78	0.95	3.73	4.00
13	128.6	122.2	5.25	0.28	1.67	1.16
14	124.0	118.0	5.17	0.31	1.91	1.00
18	123.5	117.5	5.08	0.31	1.97	1.98

TABLE VIIB RESULTS OF TRIAXIAL TESTS OF 5% and 2% CEMENT * AND GRAVEL MIXTURES

5% H. E. Cement (24 hr. cure)

Test Number	Moist Unit Wt. lbs./cu.ft.	Dry Unit Wt. lbs./cu.ft.	Moisture Content %	Lateral Pressure Kgm/sq.cm.	Deviator Stress at Failure Kgm/sq.cm.	Strain At Failure %
9	129.7	123.2	5.37	0.31	5.66	0.64
10	129.6	123.1	5.25	0.62	10.71	1.00
11	130.0	123.8	5.04	0.93	11.37	0.97
12	131.3	125.0	5.09	0.96	11.66	0.95
15	130.5	124.2	5.05	0.31	7.11	0.91
16	127.8	122.0	4.87	0.94	8.27	1.57
17	129.3	122.8	5.39	0.62	7.35	0.78
19	127.2	120.3	5.86	0.96	9.87	0.71
32	129.8	123.3	5.34	0	4.55	0.53
2% H. E. Cement (24 hr. cure)						
29	128.8	122.3	5.39	0.31	4.31	1.12
30	126.9	120.9	5.03	0.62	5.12	1.28
31	126.6	120.8	4.87	0.93	6.52	2.21

* 5 and 2% by weight of dry gravel

TABLE VIIC RESULTS OF TRIAXIAL TESTS OF LIME-FLY ASH AND CRAWFORD GRAVEL MIXTURES

Test Number	Moist Unit Wt. lbs./cu.ft.	Dry Unit Wt. lbs./cu.ft.	Moisture Content %	Lateral Pressure Kgm/sq.cm.	Deviator Stress at Failure Kgm.sq.cm.	Strain At Failure %
3.5% Quicklime - 7.0% Fly Ash * (No cure)						
20	127.0	119.8	5.97	0.31	2.94	1.48
21	126.3	119.4	5.85	0.62	3.71	1.76
22	126.7	119.9	5.69	0.96	4.95	3.30
3.5% Quicklime - 7.0% Fly Ash (1 wk.cure)						
23	126.4	119.7	5.72	0.96	6.52	1.29
28	125.2	119.3	4.99	0.31	3.55	1.34
2% Quicklime - 4.0% Fly Ash (No cure)						
24	126.8	120.2	5.49	0.31	3.02	1.26
25	127.0	120.5	5.61	0.63	3.74	1.85
26	127.7	121.3	5.21	0.94	4.96	3.12
2% Quicklime - 4.0% Fly Ash (1 wk. cure)						
27	127.9	121.7	5.09	0.93	5.99	1.56

* These percentages of admixtures are by weight of dry gravel

LEGEND

NATIVE GRAVEL
GRAVEL + 3.5% QUICKLIME AND 7.0% FLY ASH (1 WK. CURE)
GRAVEL + 3.5% QUICKLIME AND 7.0% FLY ASH (NO CURE)
GRAVEL + 2.0% QUICKLIME AND 4.0% FLY ASH (1 WK. CURE)
GRAVEL + 2.0% QUICKLIME AND 4.0% FLY ASH (NO CURE)
GRAVEL + 5.0% H.E. CEMENT (24 HR. CURE)
GRAVEL + 2.0% H.E. CEMENT (24 HR. CURE)

THE APPROPRIATE TEST NUMBER IS SHOWN NEAR EACH CURVE.

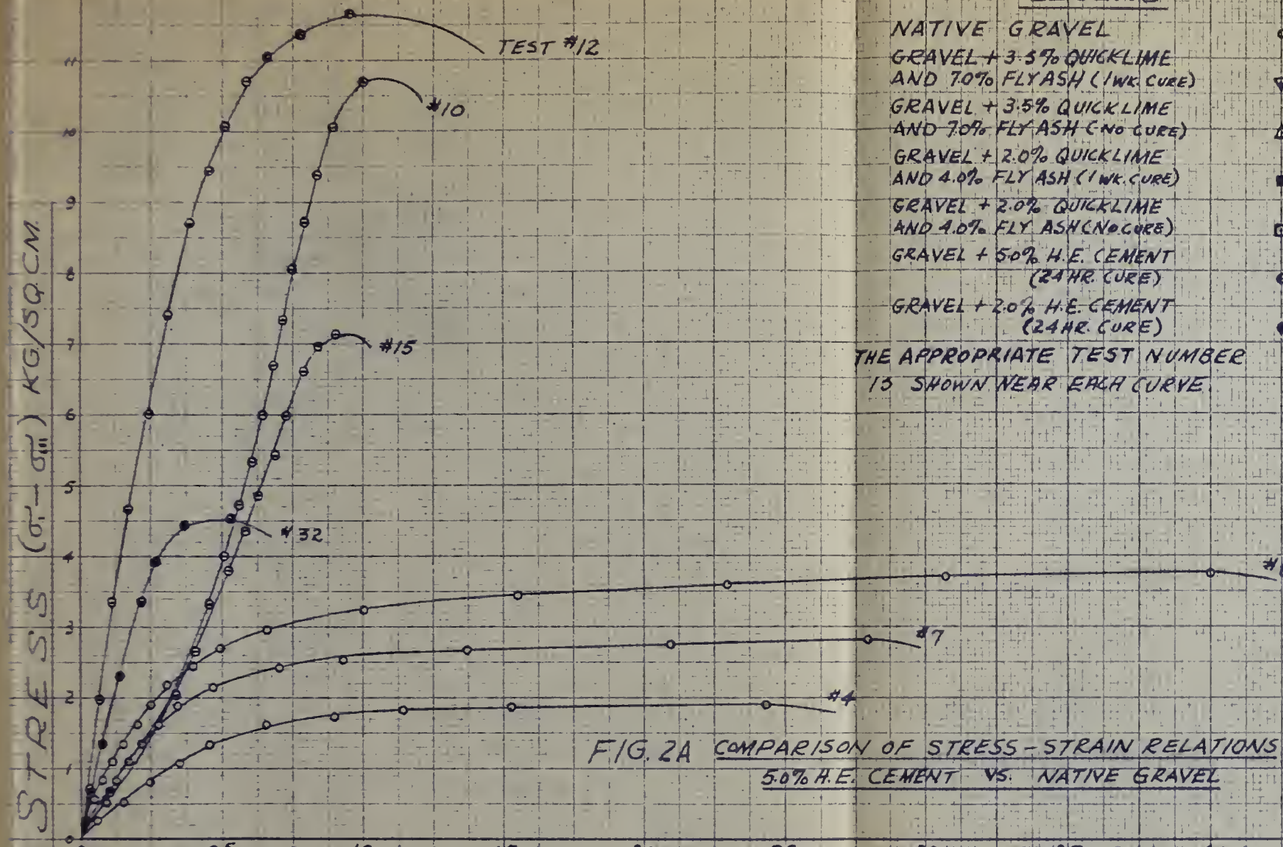


FIG. 2A COMPARISON OF STRESS-STRAIN RELATIONS
5.0% H.E. CEMENT VS. NATIVE GRAVEL

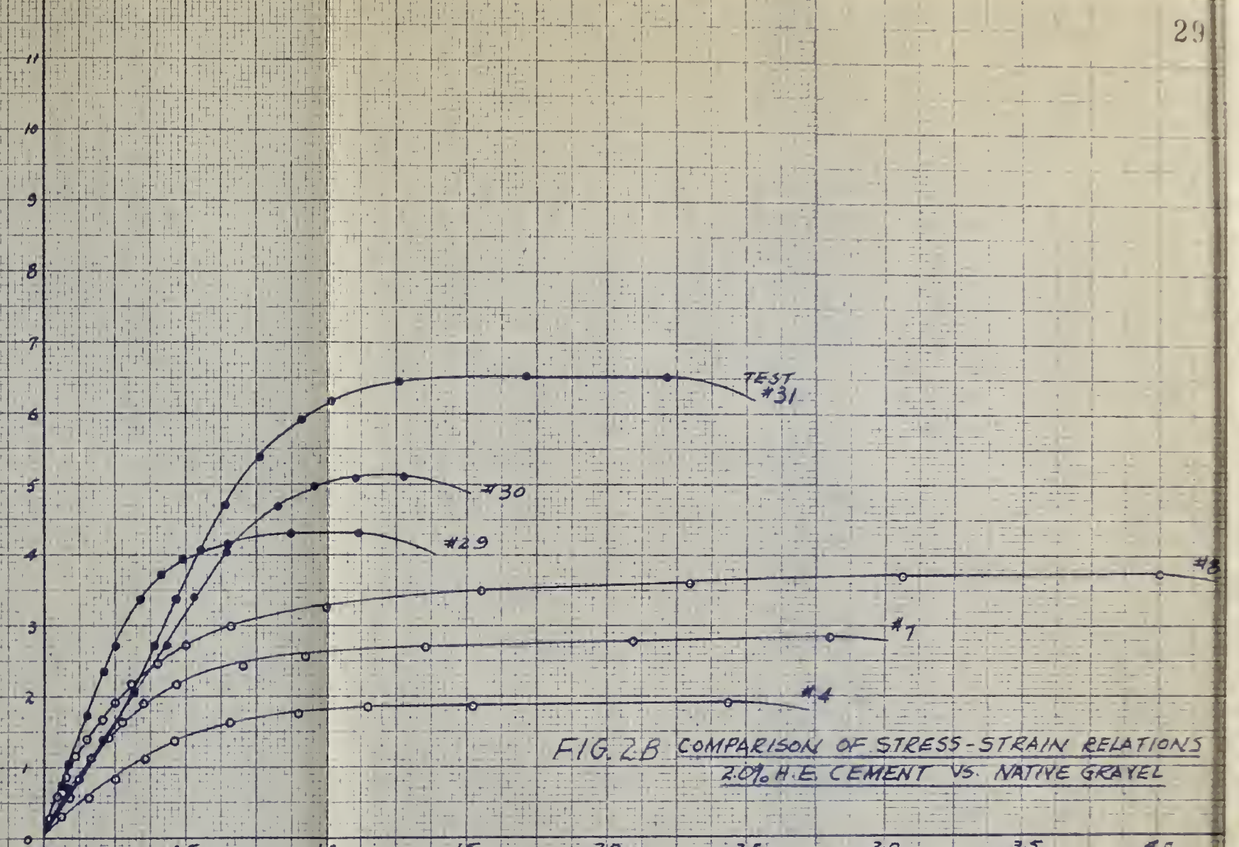


FIG. 2B COMPARISON OF STRESS-STRAIN RELATIONS
2.0% H.E. CEMENT VS. NATIVE GRAVEL

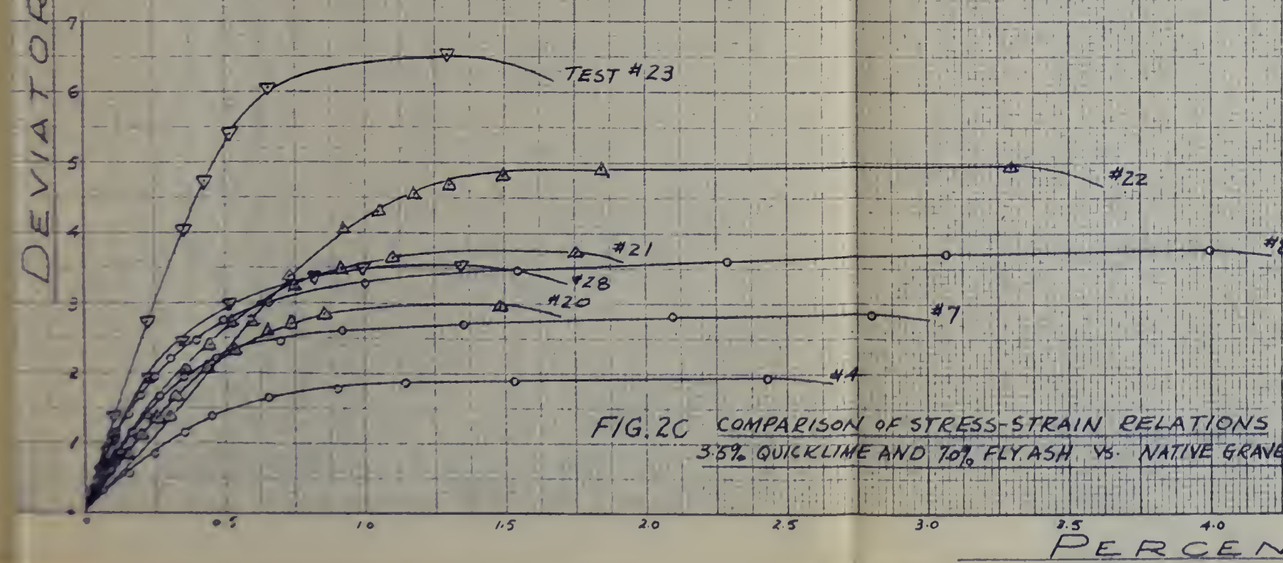


FIG. 2C COMPARISON OF STRESS-STRAIN RELATIONS
3.5% QUICKLIME AND 7.0% FLY ASH VS. NATIVE GRAVEL

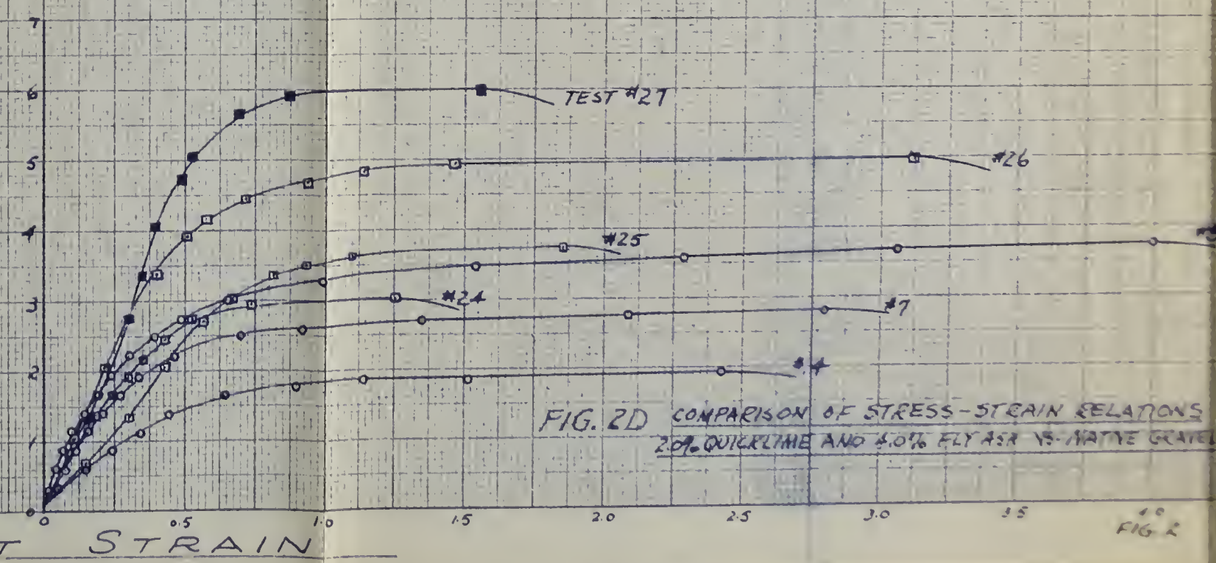


FIG. 2D COMPARISON OF STRESS-STRAIN RELATIONS
2.0% QUICKLIME AND 4.0% FLY ASH VS. NATIVE GRAVEL

DEVIATOR STRESS ($\sigma_1' - \sigma_3'$) KG/SQ CM

PERCENT STRAIN

FIG. 2

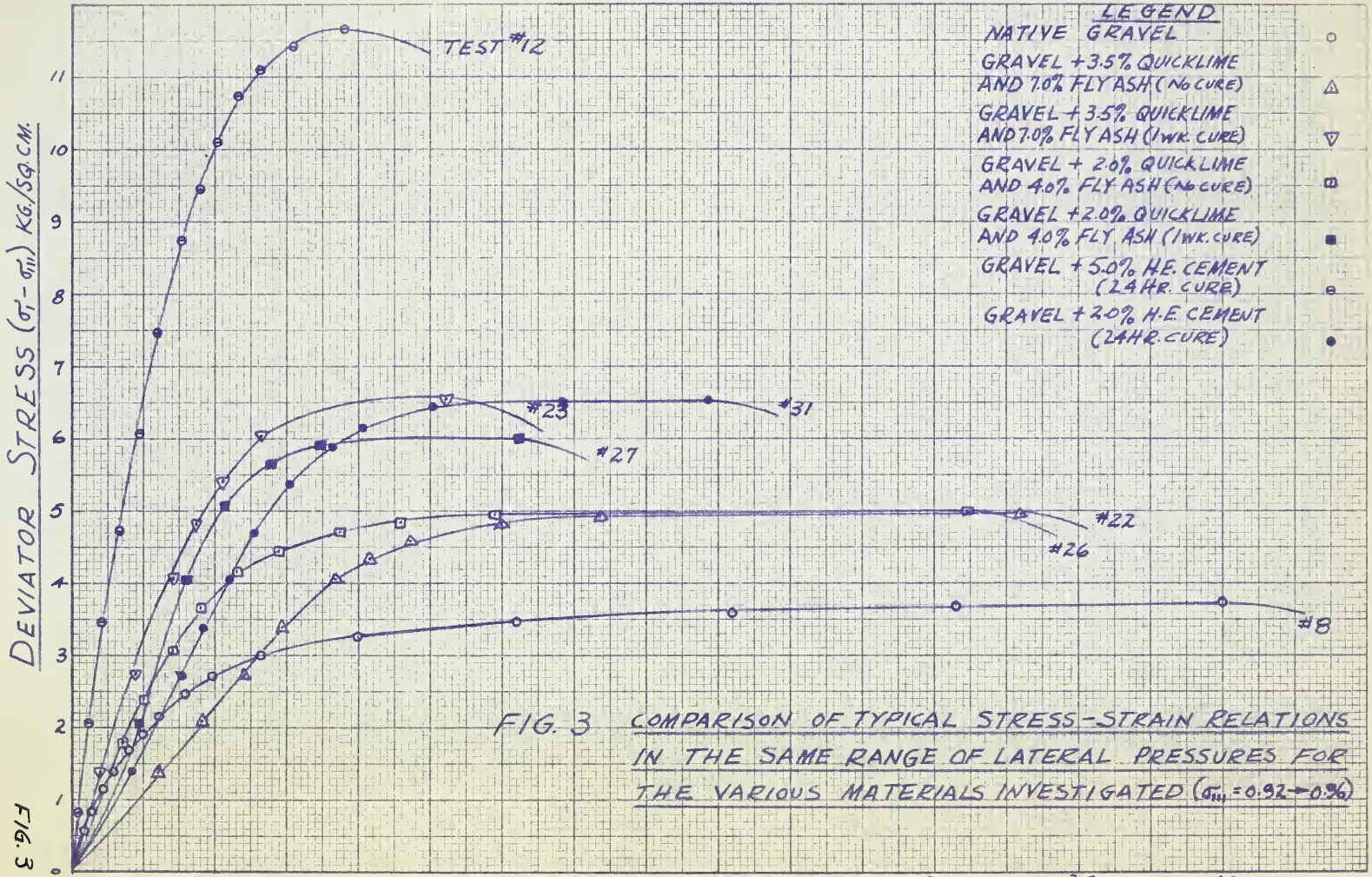


FIG. 3 COMPARISON OF TYPICAL STRESS-STRAIN RELATIONS IN THE SAME RANGE OF LATERAL PRESSURES FOR THE VARIOUS MATERIALS INVESTIGATED (σ_{111} = 0.92 → 0.96)

FIG. 3

FIG. 4A
MOHR STRESS CIRCLES AT FAILURE FOR CRAWFORD GRAVEL

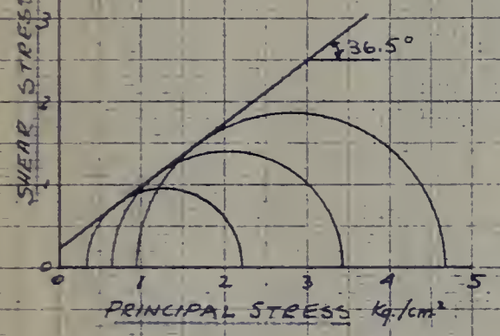


FIG. 4B MOHR STRESS CIRCLES AT FAILURE FOR CRAWFORD GRAVEL WITH 2% AND 5% HIGH EARLY CEMENT ADDED

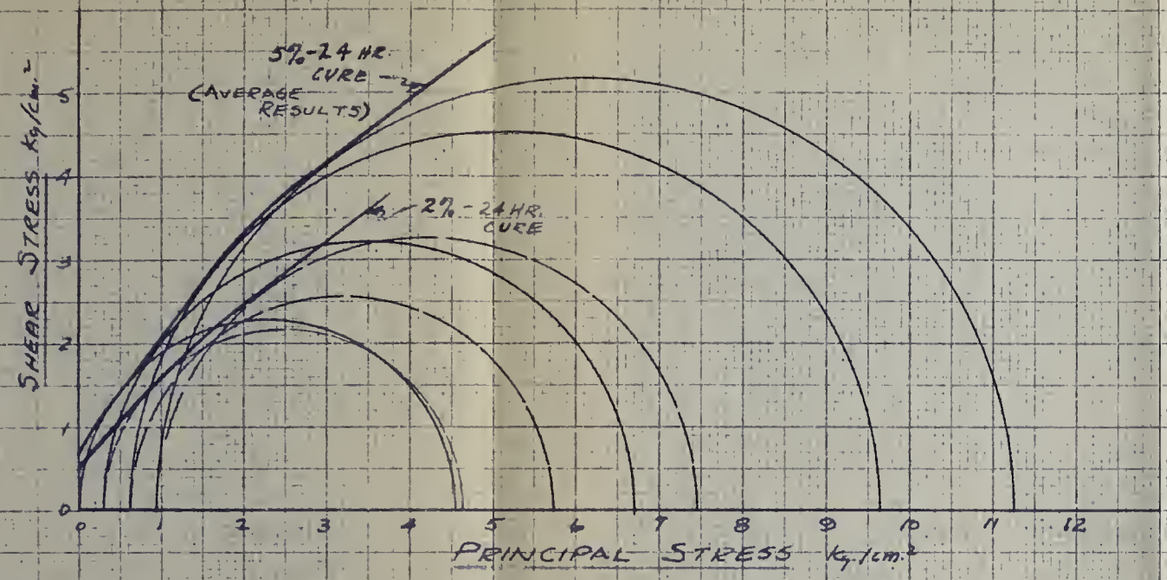
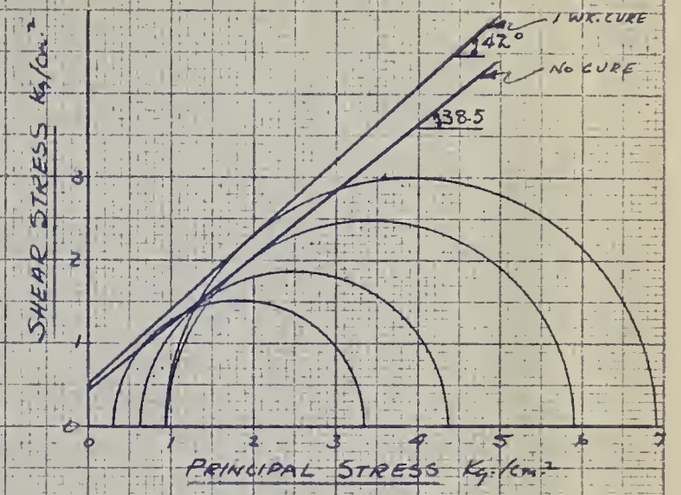


FIG. 4C
MOHR STRESS CIRCLES AT FAILURE FOR GRAVEL WITH 2% QUICKLIME AND 4% FLY ASH ADDED



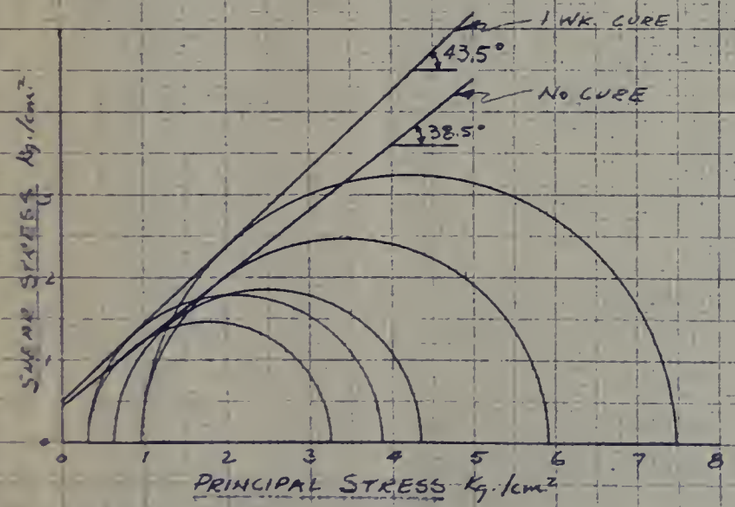


FIG. 4D MOHR STRESS CIRCLES AT FAILURE FOR GRAVEL WITH 3.5% QUICKLIME AND 7.0% FLY ASH ADDED

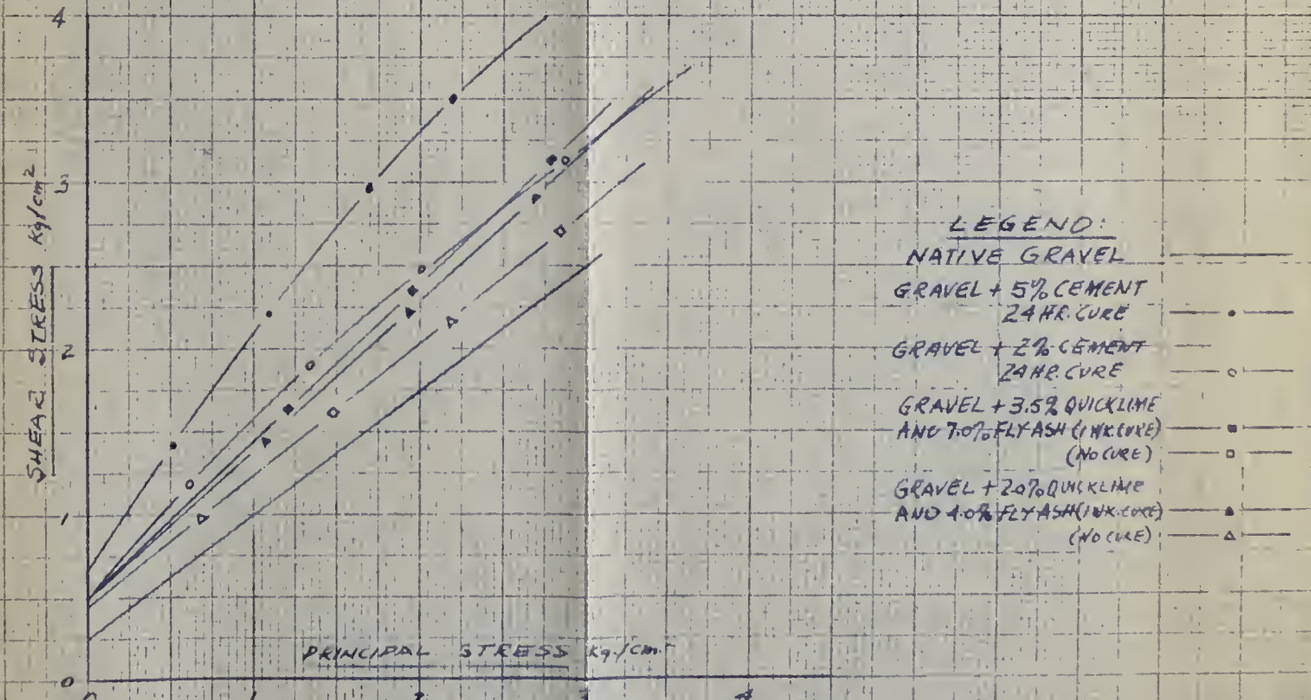

SHEAR STRESS Kg/cm²
0 1 2 3 4
PRINCIPAL STRESS Kg/cm²
LEGEND:
NATIVE GRAVEL
GRAVEL + 5% CEMENT 24 HR. CURE
GRAVEL + 2% CEMENT 24 HR. CURE
GRAVEL + 3.5% QUICKLIME AND 7.0% FLY ASH (1 WK. CURE)
(NO CURE)
GRAVEL + 2.0% QUICKLIME AND 4.0% FLY ASH (1 WK. CURE)
(NO CURE)

FIG. 5 MOHR RUPTURE LINES OBTAINED FROM FIGURES 4A, 4B, 4C, AND 4D FOR THE VARIOUS TEST SERIES

FIG. 4 & 5

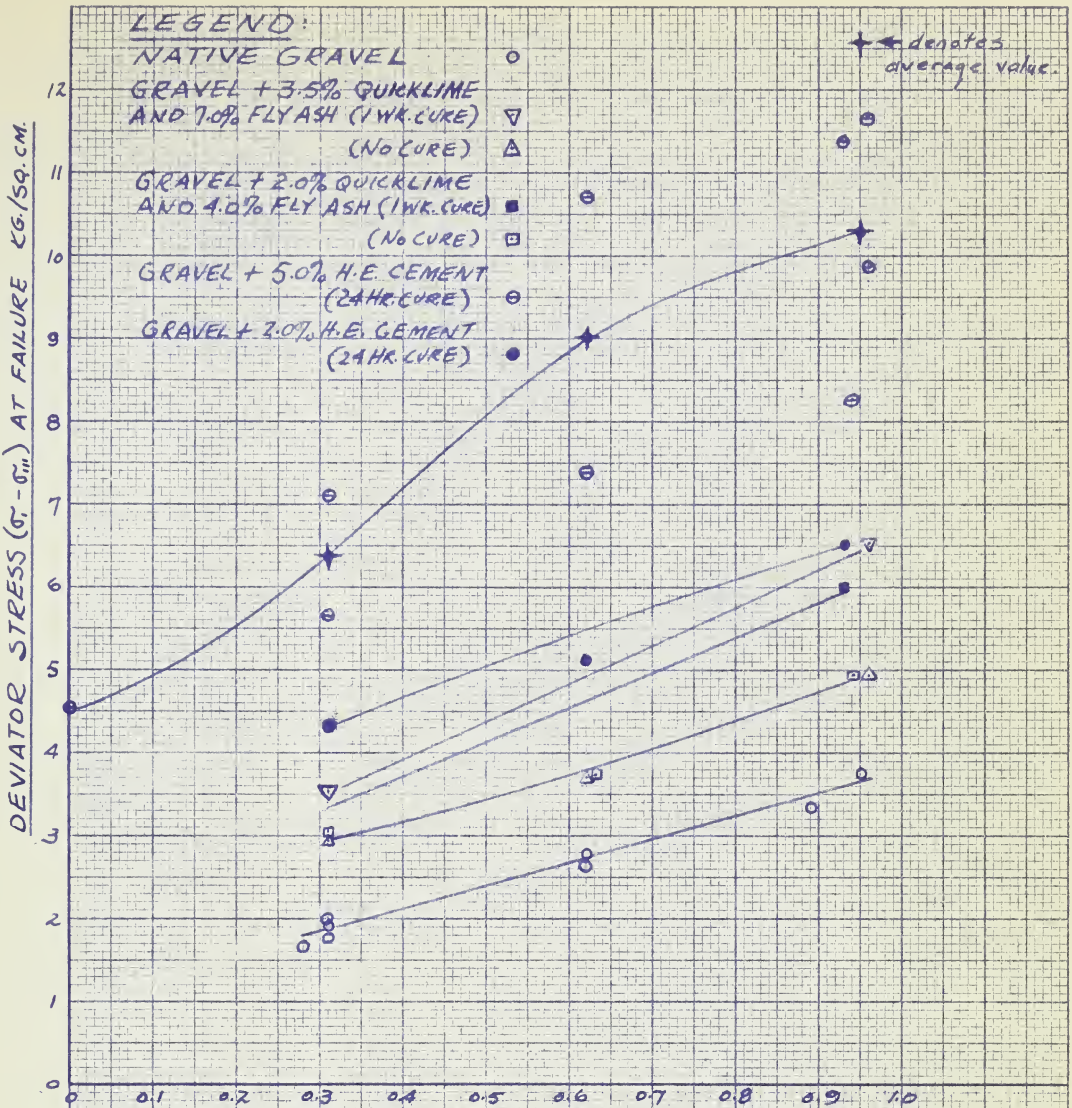

LEGEND:
NATIVE GRAVEL
GRAVEL + 3.5% QUICKLIME AND 7.0% FLY ASH (1 WK. CURE)
(No CURE)
GRAVEL + 2.0% QUICKLIME AND 4.0% FLY ASH (1 WK. CURE)
(No CURE)
GRAVEL + 5.0% H.E. CEMENT (24 HR. CURE)
GRAVEL + 3.0% H.E. CEMENT (24 HR. CURE)
+ denotes average value.
DEVIATOR STRESS ($\sigma_1 - \sigma_{III}$) AT FAILURE KG./SQ. CM.
0 1 2 3 4 5 6 7 8 9 10 11 12
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
MINOR PRINCIPAL STRESS (σ_{III}) KG./SQ. CM.

FIG. 6 COMPRESSIVE STRENGTHS AS RELATED TO TEST LATERAL PRESSURES

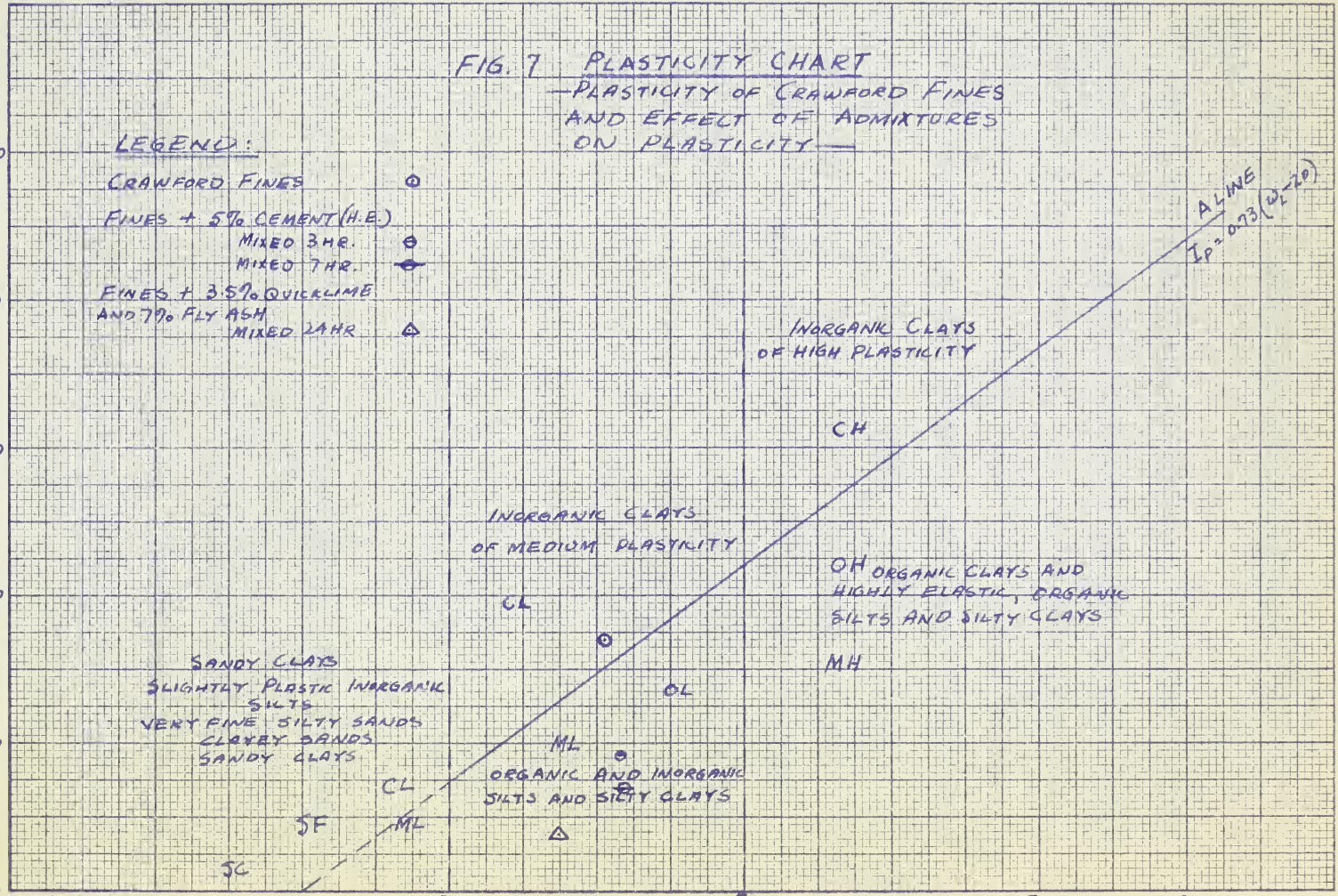


FIG. 7 PLASTICITY CHART
—PLASTICITY OF CRAWFORD FINES AND EFFECT OF ADMIXTURES ON PLASTICITY—
LEGEND:
CRAWFORD FINES
FINES + 5% CEMENT (H.E.)
MIXED 3 HR.
MIXED 7 HR.
FINES + 3.5% QUICKLIME AND 7% FLY ASH
MIXED 24 HR
A LINE
$I_P = 0.73(w_L - 20)$
INORGANIC CLAYS OF HIGH PLASTICITY
CH
INORGANIC CLAYS OF MEDIUM PLASTICITY
CL
OH ORGANIC CLAYS AND HIGHLY ELASTIC, ORGANIC SILTS AND SILTY CLAYS
MH
OL
ML
ORGANIC AND INORGANIC SILTS AND SILTY CLAYS
SANDY CLAYS
SLIGHTLY PLASTIC INORGANIC SILTS
VERY FINE SILTY SANDS
CLAYEY SANDS
SANDY CLAYS
CL
SF
ML
SC
PLASTICITY INDEX (I_P)
LIQUID LIMIT (w_L)
0
10
20
30
40
50
60
70
80

FIG. 7

CHAPTER V

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

DISCUSSION

The results obtained in this investigation indicate that the particular admixtures used with the Crawford gravel definitely improve the strength, workability and plasticity characteristics of this gravel. These results are best illustrated by Figures 5, 6 and 7. The addition of 5% High Early Strength Portland cement results in one-day compressive strengths which are approximately three times greater than the strength of the native material throughout the range of lateral pressures investigated. This can be best seen from study of Figure 6. The effects of the 2% cement admixture after one-day cure are similar in nature but of smaller magnitude. The increase in strength with this admixture was about twofold over the confining pressure range of the test carried out. The effects of the various admixtures on the strain of the compositions under test was pronounced. The strains at failure were much lower for the specimens containing admixtures and the effect was the greatest for the 5% cement series when typical strains at failure were approximately 1/4 of those obtained in tests on the native gravel. This is illustrated in Figure 3.

The admixtures of 3.5% quicklime and 7% fly ash and of 2% quicklime and 4% fly ash resulted in compressive strengths right after molding of approximately one and one-half times the magnitude of those obtained for the native gravel over the lateral pressure range investigated. This illustrates the immediate benefits of this admixture. After curing one week, specimens made up

with these admixtures resulted in compressive strengths similar to those found for the 2% cement admixture tested at one day, (i.e. nearly twice the compressive strength of the natural gravel). This shows a considerable increase in strength after a short curing period.

Of the nine triaxial tests run on 5% cement mixtures, considerable scattering of results was obtained for those tests run at the same restraining pressure. With no checks available, the average value for the test results at each confining pressure in this series was employed. This scatter of results in the 5% cement series was not a result of the type of strength test employed (vacuum triaxial) because in the ten tests on native gravel, check tests were obtained over the pressure range used with a negligible degree of scatter.

It would appear then that the large-scale triaxial method is an excellent method of evaluating unstabilized gravel strengths and that the test is quite sensitive to the increased number of variables present when admixtures are included with the gravel. No doubt small differences in moisture content of the specimens, while not appreciably affecting strength results of tests run on the native gravel, would account for some of the discrepancies obtained in the check tests performed on the 5% cement specimens. The deviations in strength results which occur in tests of concrete cylinders made from the same mix or for that matter from the same batch help to explain this scatter.

The results obtained indicate that this gravel treated with any of the particular admixtures investigated would be more effective than natural material in supporting and distributing load over the subgrade of a roadway. The 5% High Early cement admixture tested at one day showed the highest degree of improvement

and these results could be considered as being indicative of those one might obtain by using a Normal Portland cement corresponding to A.S.T.M. specifications rather than High Early cement and testing the composition at one week instead of at one day. This one week curing period would generally duplicate the length of cure allowed a cement-treated base in the field before traffic uses it.

Using Normal Portland cement from the same manufacturer as the High Early cement used in the triaxial tests would normally result in higher strength values at one week than for the High Early at one day, i.e.

H.E. Cement Used Av. 1 day Strength (From Table IV)	Normal Portland 7-day Strength A.S.T.M. Specs.	Normal Portland Av. 7 day Strength (From Same Supplier as for H.E. Cement)
2,175 psi	1,800 psi min.	3,700 psi

From Figures 2A, B, C and D moduli of deformation (slope of stress-strain curves) were computed for the initial parts of the curves or in the upper, relatively straight portion of curves which exhibited reverse bends.

These moduli of deformation were generally found to increase with the restraining pressure used in each test series. Typical values obtained for the various mixtures at the highest and lowest restraining pressures used for each test series were:

Material	Moduli of Deformation 0.9 Atmospheres Kg./cm^2	0.3 Atmospheres Kg./cm^2
Native gravel	6.0	2.7
Gravel and 5% cement	26.7	10.9
Gravel and 2% cement	8.0	10.4
Gravel and 3.5% lime, 7% fly ash		
1 week cure	9.7	8.0
no cure	4.6	4.6
Gravel and 2% lime, 4% fly ash		
1 week cure	10.9	--
no cure	8.6	5.4

These values are quite rough indications of how the various mixtures improve the stress-strain qualities of the original gravel. A deformation modulus higher in value than that for the original gravel indicates the degree to which the admixture has improved the native material in terms of a higher failure stress at reduced strain. Perhaps it is somewhat more obvious from these figures than a visual inspection of Figures 2A, B, C and D, that the 5% cement admixture created the largest improvement.

Table II and Figure 7 show the beneficial effects of the admixtures upon the plasticity of the fines contained in the Crawford gravel and illustrate that the effects produced by cement and by lime-fly ash admixtures are somewhat different but that both admixtures materially reduce the Plasticity Index of the fine material. The actual reduction in P.I. was found to be dependent on the soil type, the quantity of admixture and the length of storage before test. This agrees with observations made by other investigators[1,6,7,11].

The slopes of the various rupture lines found by drawing best fit lines (straight or curved) in Figures 4A, B, C and D and summarized in Figure 5 indicate that:

(a) the strength benefits, immediately after molding, brought about by lime-fly ash admixtures are not so much of increasing the rupture line slope but of raising its starting point (i.e. increased unconfined strength),

(b) the strength benefits derived from lime-fly ash admixtures are apparently only partially dependent upon quantity for the initial strength increase but that increases in strength with time are dependent on the quantity of admixture present,

(c) the effects of lime-fly ash improvements follow a more straight line relationship than the cement-treated specimens. The effects of the cement seem to taper

off at higher confining pressures (i.e. the rupture line flattens out and apparently approaches the slope of the rupture line of the native material).

The gravel batches which were treated with admixtures were much more easily handled by shovel than those batches mixed up for test without benefit of admixture. Since these gravel-admixture batches were at higher moisture contents than the native gravel which was tested, it shows the effect of the admixture in reducing the plasticity of the fines. This "fluffing up" or aggregation of the material was greatest in the lime-fly ash admixture compositions and they were the easiest to handle in preparing the specimens for test.

CONCLUSIONS

The following conclusions can be drawn from the results obtained from the testing program.

(1) All of the particular admixtures investigated were found to improve the strength and plasticity characteristics of this particular gravel compacted and cured in a particular manner. (The treated gravel would be superior to the native gravel in sustaining load, resisting deflection and distributing load to the subgrade.) Under field conditions, however, weathering action over prolonged periods could possibly result in reductions to these benefits.

(2) Since the High Early Strength Portland cement used in this investigation led to higher strengths after one-day cure than the 3.5% quicklime - 7% fly ash specimens tested at one week at corresponding lateral pressures, it is evident that this admixture shows promise for future use with Crawford gravel or gravels of this same type when only a short period, say 24 hours, of curing is possible for the treated base before traffic must use it.

(3) Further, it can be concluded, since the seven-day compressive strength tests on Normal Portland cement are higher than the one-day compressive

strength tests on the High Early Strength cement from the same supplier, that the use of this Normal Portland cement as an admixture would lead to generally higher results at one week than those obtained with High Early Strength cement at one day. Hence on an equal material cost basis, it is indicated that Normal Portland cement would achieve much greater strength benefits than the lime-fly ash admixtures when using the seven-day strength of the compositions as a criterion. It is estimated that the total cost of treatment with 5% Normal Portland cement would be somewhat in excess of $1.50 per cu.yd. (compacted) over and above the cost of construction with untreated material. The $1.50 figure mentioned above represents material cost only and the extra cost involved would depend upon admixture shipment costs and the difference in mixing costs between the two construction techniques.

(4) It must be concluded from such erratic strength results as were obtained in the cement test series, notwithstanding the high degree of batching control possible in the laboratory, that a higher percentage of cement will have to be added in the field to assure the same average results which are obtainable in the laboratory. The quantity of extra cement required would depend on the uniformity of the gravel being treated, the type of mixing equipment available, weather and construction methods, and the degree of control exerted in the construction operations.

(5) Minor variations in the moisture content of native gravel have little, if any, effect on the strength obtained by vacuum triaxial means at the same confining pressure. These variations in moisture content of specimens which include admixtures, as well as the length of damp mixing time before compaction, do cause scatter in the results obtained for tests at the same confining pressure. This effect was most noticeable for the 5% cement series as five check tests were run

in this series without duplicating any of the strengths obtained previously at the three confining pressures employed.

(6) There is a definite build up in strength of lime-fly ash and gravel specimens with storage but this pozzolanic action was not checked at long enough intervals in this investigation to predict how fast or how far this strength does increase. It is indicated that the degree of strength build-up is dependent on the quantity of admixture used.

(7) Without definite strength criteria for base materials established for use with large scale apparatus, it is not possible to say whether the 5% Portland cement admixture is sufficient to place the poor quality Crawford gravel into the category of a suitable subbase or base material, even with a threefold or more strength gain over the strength of the native material. Because of these strength increases, and since this admixture reduced the plasticity index of the gravel to an acceptable figure, it is the author's opinion that, barring deleterious time effects, the treated gravels would perform most satisfactorily. A test section could substantiate or disprove this theory.

(8) When compared to tests on the Crawford gravel fines, the effects of the admixtures on the optimum moisture content and maximum day density of the Modified Proctor compaction tests carried out were:

(a) to decrease the optimum moisture content and increase the maximum dry density of cement-treated samples,

(b) to increase the optimum moisture content and decrease the maximum dry density of lime-fly ash treated samples.

These results generally agree with results obtained by other investigations[1,6,11]. In compacting the large triaxial specimens (1/2 Standard Proctor compactive effort) it was found that the lime-fly ash specimens had densities slightly in excess of

those obtained for the native gravel, and that the densities of the cement-treated gravel were higher than either.

RECOMMENDATIONS FOR FUTURE RESEARCH

(1) It is recommended that a set of rupture lines for materials considered as excellent subbase, base and surface course aggregate be obtained with this large scale vacuum triaxial equipment. Hence, criteria would be available with which to compare the results of tests on stabilized gravels. In this way it would be seen which sub-marginal gravels can be economically treated so that they would be useable in their stabilized condition.

(2) If a great number of these large scale triaxial tests were to be undertaken, then it is advisable that a different method of compaction be devised. Possibly a larger version of the vibrating-spring load compactor as used elsewhere [15] would be best suited to this purpose.

(3) The effects of longer curing periods coupled with those of weathering upon the permanency of the strength and plasticity benefits to the gravel resulting from the use of these admixtures could be investigated. A more complete investigation of admixture types and quantities for adequate reduction of plasticity is warranted.

(4) Work done by Wright and Roy [8] indicates that, depending on soil type, approximately 15 to 25% of the cement ordinarily used for cement stabilization may be replaced by fly ash without serious loss of strength. This represents a considerable saving in the cost of stabilization and might well be investigated in the case of submarginal gravels.

(5) Work could be carried out with this same gravel, keeping the same ratio of maximum sized particle to specimen diameter, with a smaller vacuum triaxial apparatus (say 5.6 in. diameter) in an attempt to determine quantitatively the effect of the larger sizes on strength.

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APPENDIX A

CLASSIFICATION AND IDENTIFICATION TEST DATA

APPENDIX A

GRADING REQUIREMENTS FOR SOIL-AGGREGATE MATERIALS*
(Subbase, Base and Surface Courses)
A.A.S.H.O. Designation: M 147-49

Types	Type I			Type II		
	Percentage by weight passing square mesh sieves					
Sieve Designation	Grading A	Grading B	Grading C	Grading D	Grading E	Grading F
2-inch	100	100	--	--	--	--
1-inch	--	--	100	100	100	100
3/8-inch	30-65	40-75	50-85	60-100	---	--
No. 10	15-40	20-45	25-50	30-65	40-100	55-100
No. 40	8-20	10-25	12-30	15-40	20-50	30-70
No. 200	2-8	3-10	4-12	5-15	6-20	8-25

*Note: Soil-aggregate materials for surface course shall conform to requirements for Type I, grading C or D, or Type II, grading E or F. The type and grading shall be designated. (Where it is planned that the soil aggregate surface course is to maintained for several years without bituminous surface treatment or other superimposed impervious surfacing, the engineer should specify a minimum of 8 percent passing No. 200 sieve in lieu of the minimum percentages shown in Table 1 for grading C, D, or E, and should specify a maximum liquid limit of 35 and plasticity index range of 4 to 9 in lieu of the limits given in Section 4 (b).)

("4b. The fraction passing the No. 200 sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve. The fraction passing No. 40 sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6.")

ADMIXTURE QUANTITIES

It was thought that one of the better ways to compare admixtures was to compute percentages of each that would result in the same material cost. The admixture then giving the greater strength increase would be the better.

Since it was decided that 5% cement was the maximum quantity that might be economically incorporated in a mixture, it was then necessary to find a combination of quicklime and fly ash which would result in the same cost.

Using local prices, the following analysis was carried out:

Bulk Normal Portland Cement (cost/lb.) = 0.889 cents,

Bulk Pulverized Quicklime (cost/lb.) = 1.1 cents,

Fly Ash (cost/lb.) = 0.10 cents.

Now using a figure of 125 lbs./cu.ft. as the compacted dry density of the cement stabilized gravel and considering a compacted thickness of 6 ins. of subbase, the cost of cement (material only) would be:

$$4.5 \times 125 \times \frac{5}{100} \times 0.889 = \$ .25 \text{ per sq.yd.}$$

The quantity of quicklime and fly ash was then found in the following manner. The dry density of the compacted lime-fly ash, aggregate composition was assumed to be 120 lbs/cu.ft. It was further decided that a 2 : 1 ratio by weight of fly ash to quicklime would be employed.

Let x = desired % of quicklime,

$$\text{then } \left(4.5 \times 120 \times \frac{x}{100}\right) 1.1 + \left(\frac{2x}{100}\ 4.5 \times 120\right) 0.1 = 25$$

Solving, we find that the required amount of quicklime = 3.5% by weight of dry aggregate and the fly ash required is then 7.0%. A 3.5% quicklime - 7.0% fly ash mixture would result in the same material cost as 5% Normal Portland cement.

SPECIMEN MOLDING MOISTURE CONTENTS

From Table III, which shows the results of four test series, the following approximate values of molding water contents for triaxial specimen molding were extrapolated.

(a) To obtain the optimum moisture content value for 1/2 Standard Proctor compaction on the -#4 material alone, the same percentage difference between the optimum moisture content for Modified and 1/2 Standard for the fines and 5% cement was applied to the optimum value found in the Modified test on the fines alone.

i.e. Moisture Content = $\frac{12.0}{8.8} \times 9 = 12.3\%$

(b) Similarly the desired moisture content for Modified Proctor compaction on the 3.5% quicklime, 7% fly ash mix would be $\frac{8.8}{12.0} \times 15.8 = 11.6\%$

(c) The desired moisture contents for 1/2 Std. compaction when employing 2% cement or 2% quicklime, 4% fly ash then was found in a similar manner.

		1/2 Std. Proctor Compactions Optimum Moisture content
Fines alone	=	12.3%
Fines + 2% cement	=	$12.3 - \frac{2}{5} \times .3 = 12.2\%$
Fines + 5% cement	=	12.0%
Fines + 2% quicklime and 4% fly ash	=	$12.3 + \frac{6}{10.5} \times 3.5 = 14.2\%$
Fines + 35% quicklime and 7% fly ash	=	15.8

Now in planning on how much water to add to a 200-lb. batch of gravel containing 80 lbs. of -#4 material and 120 lbs. of +#4 material so that the fines would have approximately the desired moisture content for the triaxial test series being run, this was the procedure followed.

With the 5% cement test series, for example, 12% moisture is desired in the fines during molding. The fines consist of 80 lbs. of Crawford gravel fines and 10 lbs. of H.E. cement.

The water required for addition to the fines is then .12 x 90 = 10.8 lbs.

Allowing 1.2 lbs. (1%) for absorption and surface water in the coarse material gives a total of 12.0 lbs. of water or 5.71% by total weight of aggregate and cement.

Maximum compressive strength, however, does not usually occur at the optimum moisture content for maximum dry density but at a molding moisture content slightly less than this value[1]. From Figure 2 of bibliographical source 1 the moisture content at maximum compressive strength is approximately 95% of that for maximum dry density. This figure when applied to the optimum value found above changes the desired molding moisture content for the strength specimens from 5.71% to 5.42%. Actual moisture contents that were measured after test in the 5% cement series ranged from 4.87% to 5.86% and averaged 5.24% for the eight tests carried out with this additive.

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SIEVE ANALYSIS

PROJECT	
SITE	
SAMPLE	
LOCATION	CRAWFORD PIT
HOLE	DEPTH
TECHNICIAN	DATE

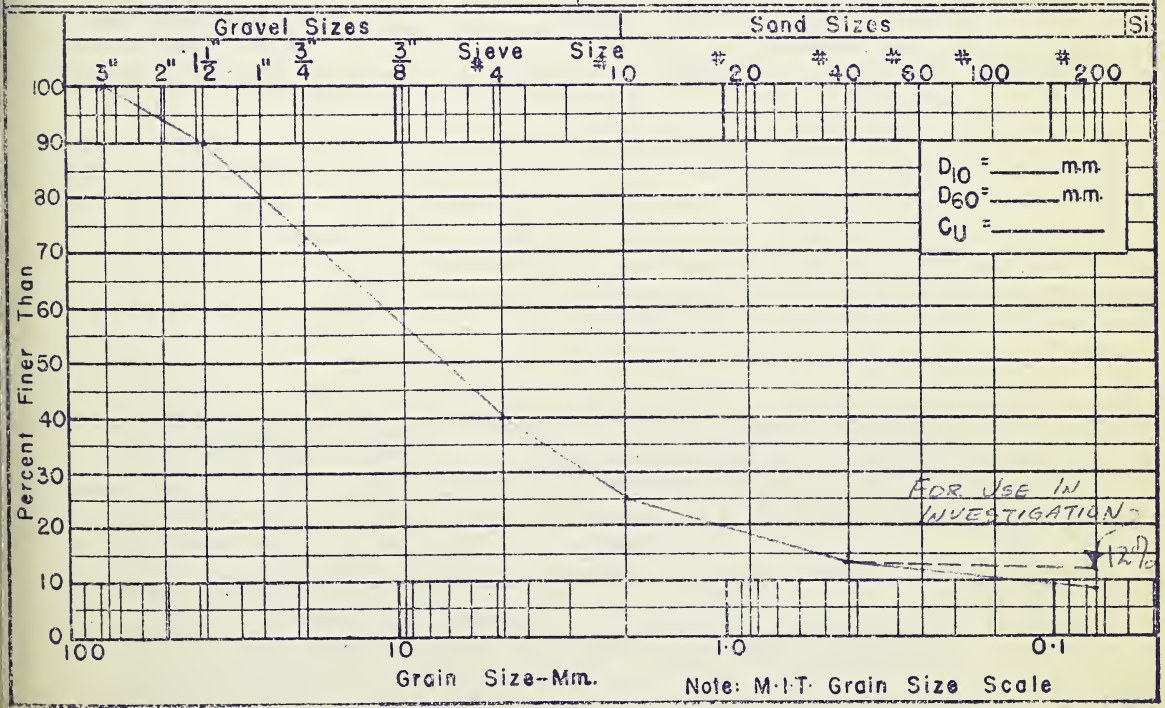
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				90	
Tare		¾	19·10			73	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					40	
Initial Dry Weight Passing No. 4							
Tare No.	10	·079	2·000			25	
Wt. Dry + Tare	20	·0331	·840				
Tare	40	·0165	·420			14	
Wt. Dry	60	·0097	·250				
	100	·0059	·149				
	200	·0023	·074				
Passing	200					8.9 (12.)	

Description of Sample

Time of Sieving

Method of Preparation

Remarks Average results of 12 sieve analyses of material from different parts of pit.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
FOR USE IN INVESTIGATION - 12½
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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HYDROMETER TEST

PROJECT
SITE
SAMPLE — #1 Material
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE Mar 23/58

Date	Temp. °C	Time	Elapsed Time	R'_h	$R_h = R'_h + c_m$	D m.m.	$R_h + m_t - c_d$	W %	W % Basis Orig. Sample	Remarks
May 23		9:00 AM								
			15"	12.0	12.5	.0192	18.9	47.6	11.9	
			30"	10.1	10.6	.0134	16.0	40.3	10.1	
		9:01	1'	8.1	8.6	.0097	14.0	35.3	8.8	
		9:02	2'	6.6	6.7	.0069	12.1	30.5	7.6	
	23.75	9:04	4'	5.2	5.8	.0049	11.2	28.2	7.0	
	23.74	9:08	8'	4.2	4.7	.0035	10.1	25.4	6.3	
	23.73	9:15	15'	3.3	3.8	.0025	9.2	23.2	5.8	
	23.69	9:30	30'	2.6	3.1	.0018	8.0	20.2	5.0	
	23.51	10:00	1h	2.2	2.7	.0013	7.1	17.9	4.5	
	23.30	11:00	2h	1.9	2.4	.0009	6.2	15.6	3.9	
	23.10	1:00 PM	4h	1.7	2.2	.0006	5.0	12.6	3.2	
	22.70	5:00	8h	1.5	2.0	.0004	4.7	11.8	3.0	
May 24	22.40	9:00 AM	24h	1.1	1.6	.0003	3.8	9.6	2.4	
May 25	22.50	10:00 AM	49h	1.0	1.5	.0002	2.7	6.8	1.7	
May 25	22.50	7:00 PM	58h	1.0	1.5	.0002	2.5	6.3	1.6	

Hydrometer No.s C78E and _____ Graduate No. _____

$W\% = \frac{100}{W_s} \cdot \frac{S_s}{S_s - 1} (R_h + m_t - c_d) =$ 2.5 $(R_h + m_t - c_d)$

Meniscus correction = c_m = _____ and _____ respectively

Dispersing agent used CALGON Amount 4% by wt

Correction for change in density of liquid due to addition of dispersing agent = c_d

c_d = _____ and _____ respectively

Specific Gravity of Solids = G_s 2.67

Description of Sample

Method of Preparation

Remarks

Initial Moisture Content

Container No. B-1
Wt. Sample Wet + Tare 131.76
Wt. Sample Dry + Tare 129.43
Wt Water 2.33
Tare Container 66.25
Wt. of Dry Soil 63.18
Initial Moisture w % 3.7

Dry Weight of Sample

Container No. C-5
Wt. Sample (Wet/Dry) + Tare 108.20
Tare 43.20
Wt. (Wet/Dry) Soil 65.0
Dry Weight from Initial Moisture = $\frac{100 \times \text{Wt. Wet Soil}}{100 + \text{Init. Moist.}\%}$ = 63.2

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SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21194
LOCATION CRANFORD PIT
HOLE DEPTH
TECHNICIAN DATE MAR 7/58

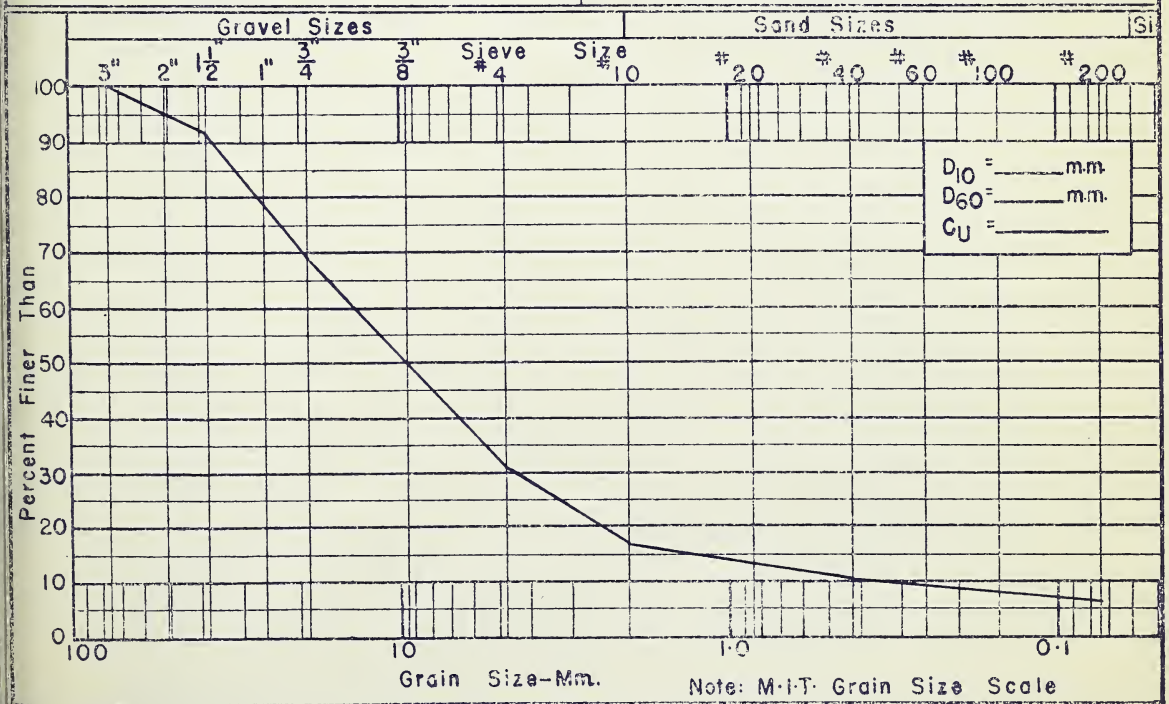
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
~~Tare No.~~		3"				100	
Wt. Dry + Tare		1½"				91	
Tare		¾"	19·10			69	
Wt. Dry		⅜"	9·52			—	
	4	·185	4·76			31	
~~Passing~~	~~4~~						
Initial Dry Weight Passing No. 4							
Tare No.	10	·079	2·000			17	
Wt. Dry + Tare	20	·0331	·840				
Tare	40	·0165	·420			9.9	
Wt. Dry	60	·0097	·250			—	
	100	·0059	·149			—	
	200	·0029	·074				
Passing	200					6·3	

Description of Sample W_L = 34.5
W_P = 18.0
P.I. = 16.5
% OVERAGE = 10

Time of Sieving

Method of Preparation - air dried
- overage removed.

Remarks Test performed at Alta. Dept. of Highways Matls lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY

SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21995
LOCATION CRAWFORD PIT.
HOLE DEPTH
TECHNICIAN DATE MARCH 7/58

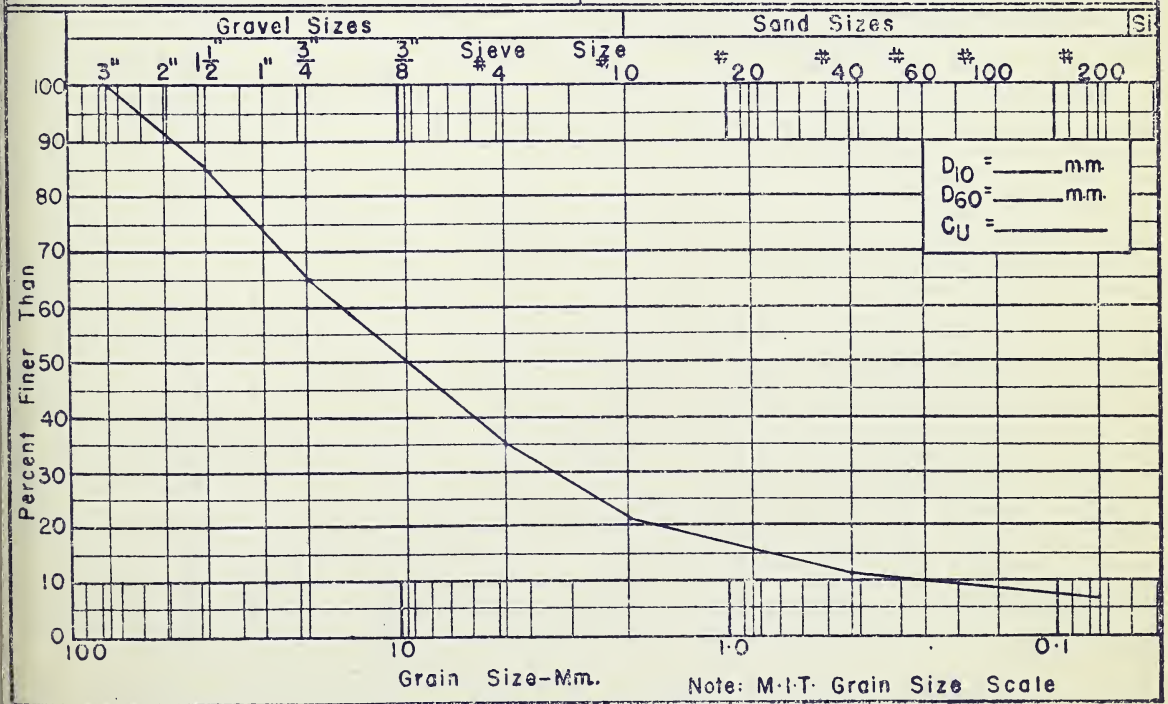
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight							
Retained No. 4							
Tare No.		3				100	
~~Wt~~ Dry + Tare		1½				85	
Tare		¾	19·10			65	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					35	
Initial Dry Weight							
Passing No. 4	10	·079	2·000			21	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			11	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					6.7	

Description of Sample W_L = 35.1
W_P = 23.8
P.I. = 11.3
Toverage = 0

Time of Sieving

Method of Preparation - air dried

Remarks Test performed at Highways Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY
SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21996
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE MAR 7/58

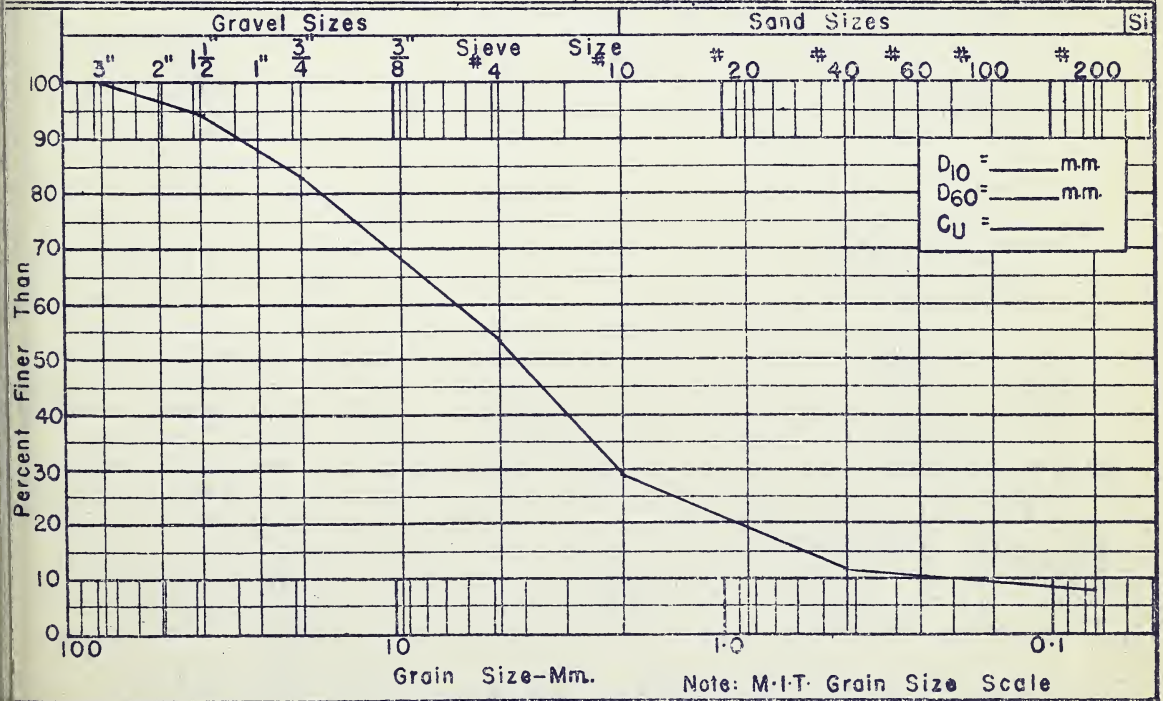
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				94	
Tare		¾	19·10			83	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					53	
Initial Dry Weight Passing No. 4	10	·079	2·000			29	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			12	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					7.8	

Description of Sample $w_L = 38.7$, $w_P = 19.5$, $P.I. = 19.2$, % overage = 4

Time of Sieving

Method of Preparation - air dried - overage removed

Remarks Test done at Highways Lab.



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SOIL MECHANICS LABORATORY
SIEVE ANALYSIS

PROJECT	
SITE	
SAMPLE	21197
LOCATION	CRAWFORD PIT
HOLE	DEPTH
TECHNICIAN	DATE MAR 7/58

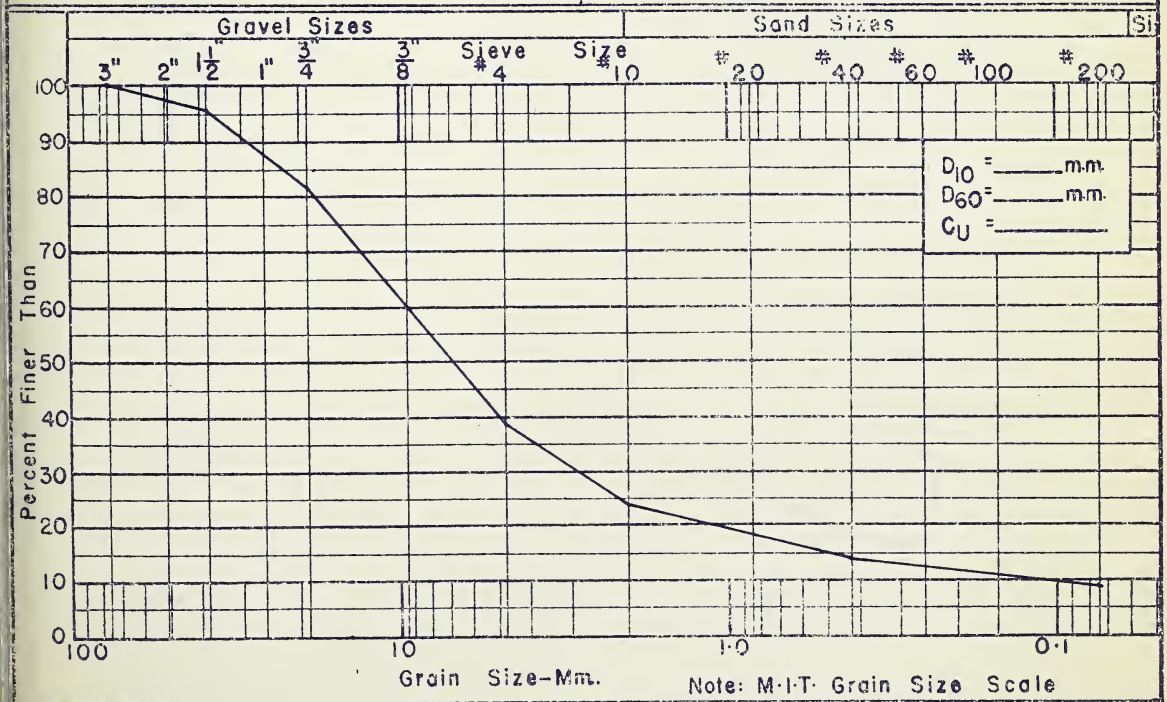
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight							
Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				96	
Tare		¾	19·10			82	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					39	
Initial Dry Weight							
Passing No. 4	10	·079	2·000			24	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			14	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					9.	

Description of Sample: $w_L = 38.0$; $w_p = 19.1$; P.I. = 18.9; % overage = 0

Time of Sieving:

Method of Preparation: - air dried

Remarks: Sample tested at Highway's Lab.



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SIEVE ANALYSIS

PROJECT	
SITE	
SAMPLE	21198
LOCATION	CRAWFORD PIT
HOLE	DEPTH
TECHNICIAN	DATE MAR 7/58

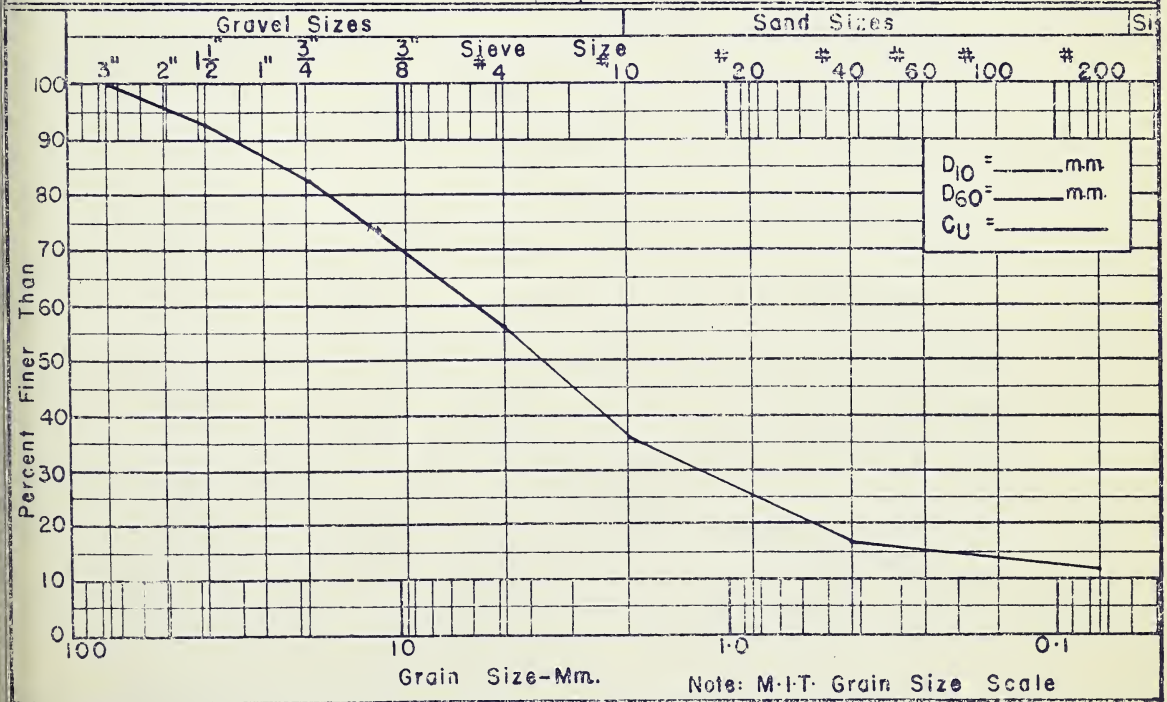
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				93	
Tare		¾	19·10			83	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					56	
Initial Dry Weight Passing No. 4	10	·079	2·000			36	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			17	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					12	

Description of Sample: w_L = 44.9; w_P = 23.0; P.I. = 21.9; % overage = 2

Time of Sieving:

Method of Preparation: - air dried - overage removed.

Remarks: Sample tested at Highway Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY
SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21199
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE MAR 7/58

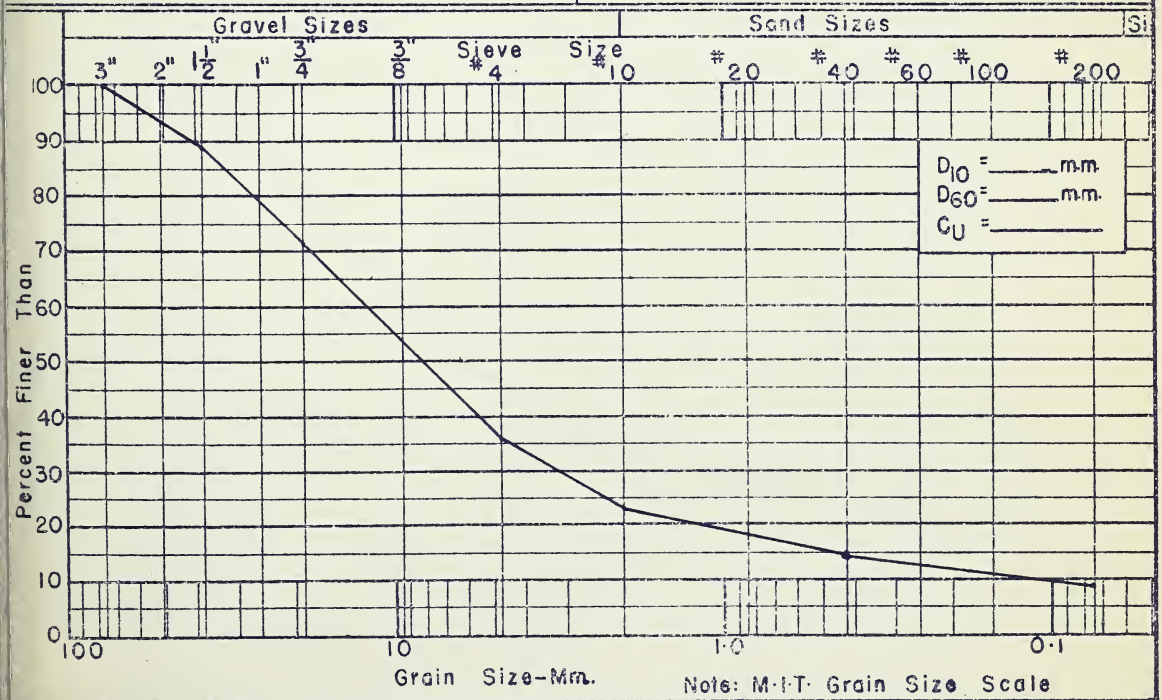
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				89	
Tare		¾	19·10			72	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					36	
Initial Dry Weight Passing No. 4							
	10	·079	2·000			23	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			15	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					9.3	

Description of Sample: $w_L = 31.2$; $w_P = 17.3$; $P.I. = 13.9$; % overage = 11

Time of Sieving

Method of Preparation: - air dried; - overage removed

Remarks: Sample tested at Highway Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
Percent Finer Than
100 90 80 70 60 50 40 30 20 10 0
100 10 1·0 0·1
Grain Size-Mm.
D10 = ____ m.m.
D60 = ____ m.m.
CU = ____

Notes: M·I·T· Grain Size Scale

UNIVERSITY of ALBERTA
DEP'T. of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY
SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 2/200
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE MAR 7/58

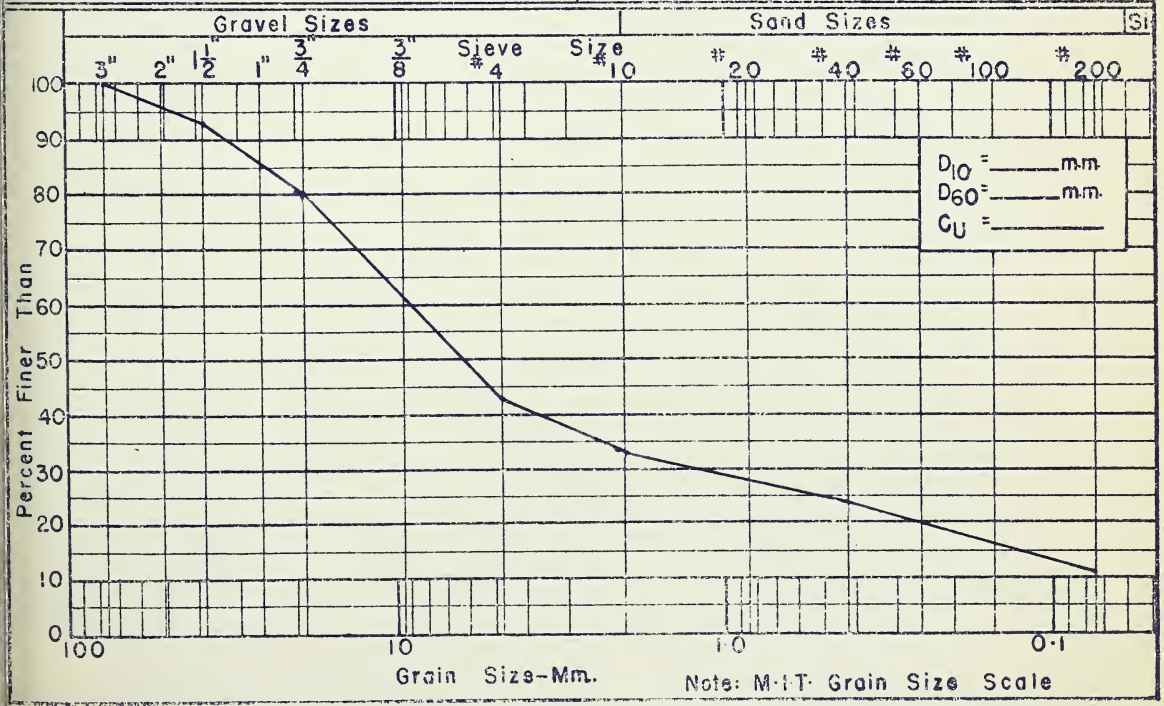
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				93	
Tare		¾	19·10			80	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					43	
Initial Dry Weight Passing No. 4							
	10	·079	2·000			33	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			24	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					11	

Description of Sample $w_L = 24.8$, $w_P = 15.4$, P.I. = 9.4, % overage = 0

Time of Sieving

Method of Preparation - air dried

Remarks Sample tested at Highway Lab.



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SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21201
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE MAR 7/58

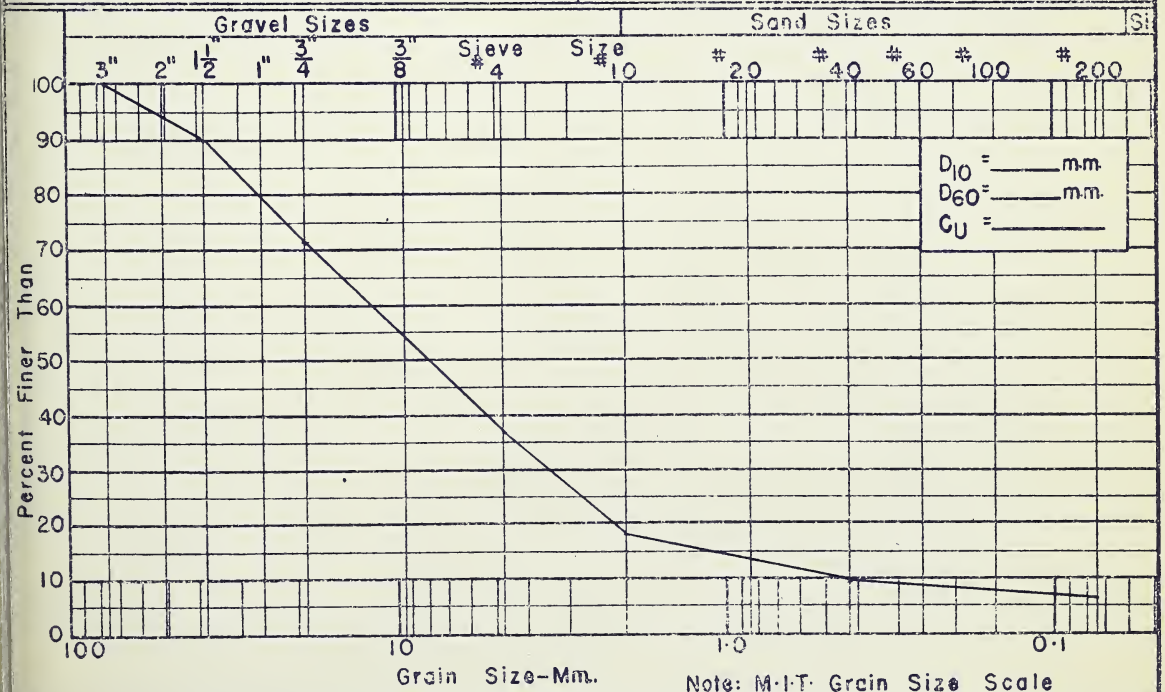
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight							
Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				90	
Tare		¾	19·10			72	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					37	
Initial Dry Weight							
Passing No. 4	10	·079	2·000			18	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			9.7	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					6.4	

Description of Sample $w_L = 39.1$, $w_p = 21.6$, P.I. = 17.5, % overage = 7

Time of Sieving

Method of Preparation - air dried - overage removed

Remarks Sample tested at Highway Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY
SIEVE ANALYSIS

PROJECT	
SITE	
SAMPLE	21202
LOCATION	CRAWFORD PIT
HOLE	DEPTH
TECHNICIAN	DATE MAR 7/58

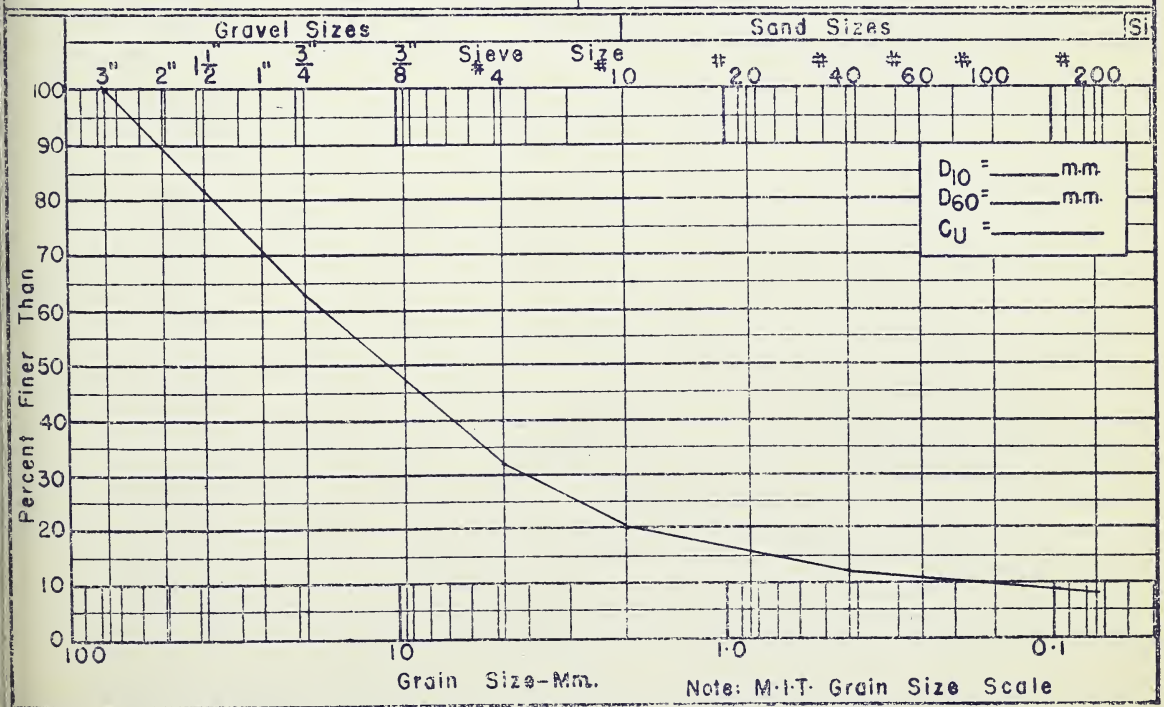
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				82	
Tare		¾	19·10			63	
Wt. Dry		⅜	9·52			~~31~~	
	4	·185	4·76				
Passing	4					32	
Initial Dry Weight Passing No. 4							
Tare No.	10	·079	2·000			20	
Wt. Dry + Tare	20	·0331	·840				
Tare	40	·0165	·420			12	
Wt. Dry	60	·0097	·250				
	100	·0059	·149				
	200	·0029	·074				
Passing	200					7.8	

Description of Sample $w_L = 38.3$
$w_P = 22.6$
P.I. = 15.7
% coverage = 8

Time of Sieving

Method of Preparation - air dried
- coverage removed

Remarks Sample tested at Highway Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY

SIEVE ANALYSIS

PROJECT	
SITE	
SAMPLE	21203
LOCATION	CRAWFORD PIT
HOLE	DEPTH
TECHNICIAN	DATE MAR 7/58

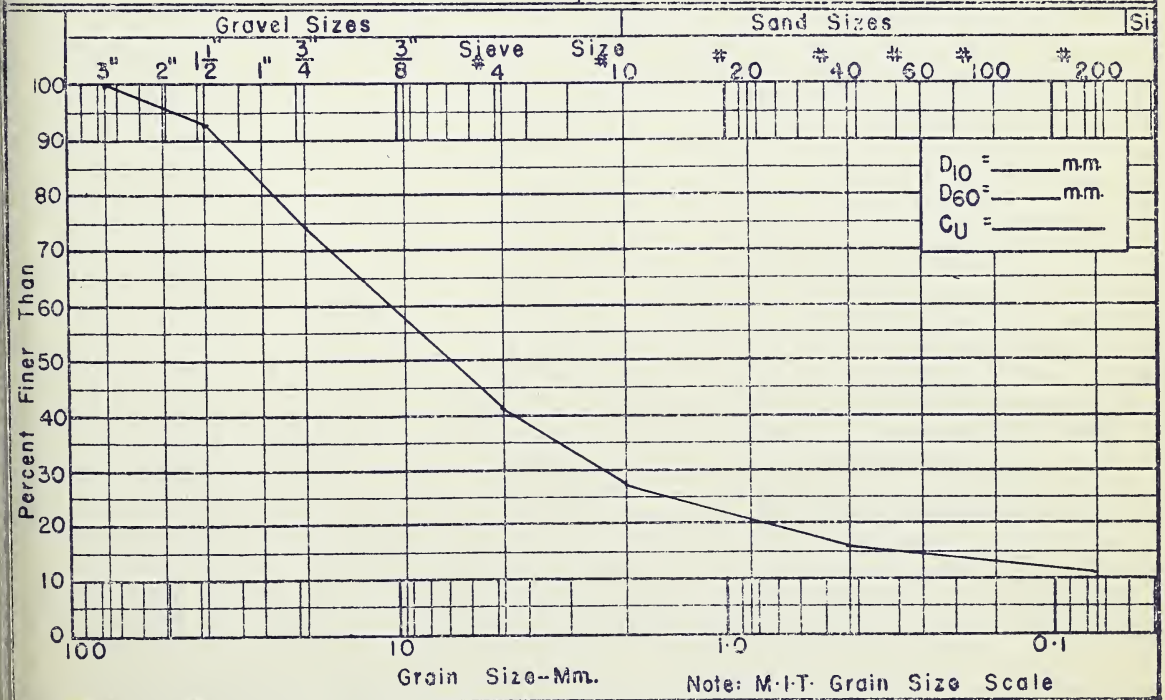
Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				93	
Tare		¾	19·10			74	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					41	
Initial Dry Weight Passing No. 4							
	10	·079	2·000			27	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			16	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074			11	
Passing	200						

Description of Sample: w_L = 40·3; w_P = 20·9; P.I. = 19·1; % overage = 3

Time of Sieving:

Method of Preparation: air dried - overage removed.

Remarks:


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY

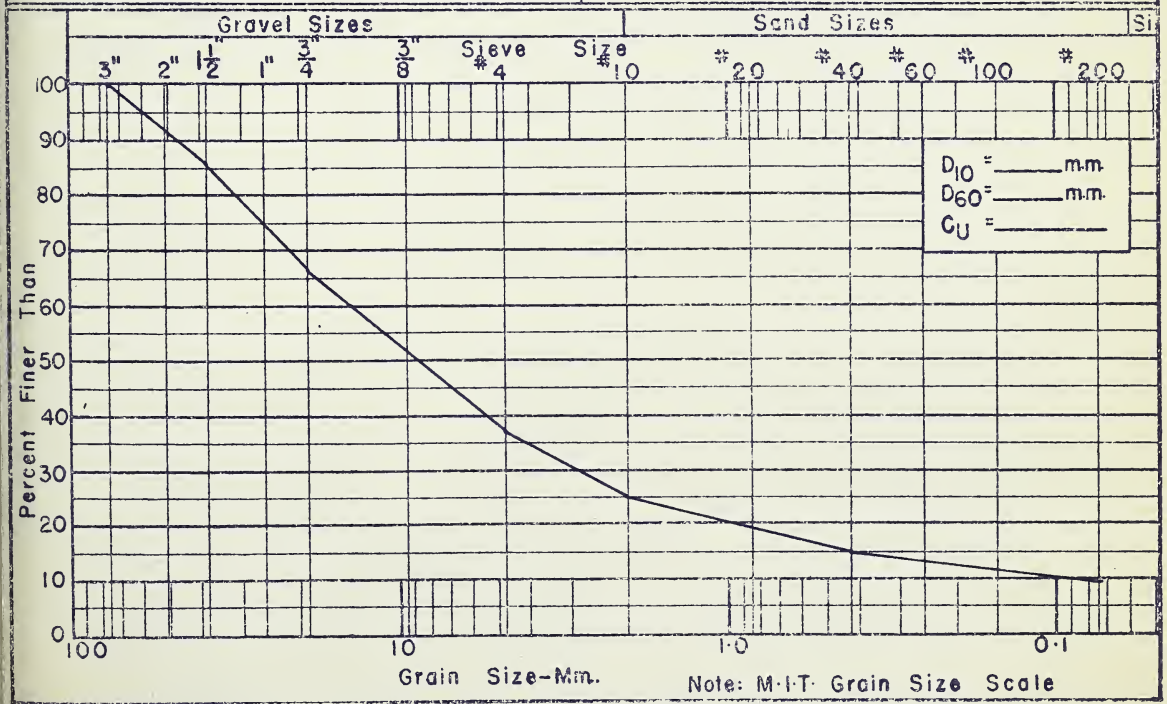
SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21473
LOCATION CRAWFORD Pit
HOLE DEPTH
TECHNICIAN DATE APRIL 28/58

Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				86	
Tare		¾	19·10			67	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					37	
Initial Dry Weight Passing No. 4	10	·079	2·000			25	
Tare No.	20	·0331	·840				
Wt. Dry + Tare	40	·0165	·420			15	
Tare	60	·0097	·250				
Wt. Dry	100	·0059	·149				
	200	·0029	·074				
Passing	200					9.5	

Description of Sample
% overage = 8
Time of Sieving

Method of Preparation - air dried and overage removed
Remarks Sample tested at Highway Lab.


Gravel Sizes
Sand Sizes
Sieve Size
3" 2" 1½" 1" ¾" ⅜" #4 #10 #20 #40 #60 #100 #200
100 90 80 70 60 50 40 30 20 10 0
Percent Finer Than
D_{10} = ____ m.m.
D_{60} = ____ m.m.
C_U = ____
100 10 1·0 0·1
Grain Size-Mm.
Note: M·I·T· Grain Size Scale

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SOIL MECHANICS LABORATORY

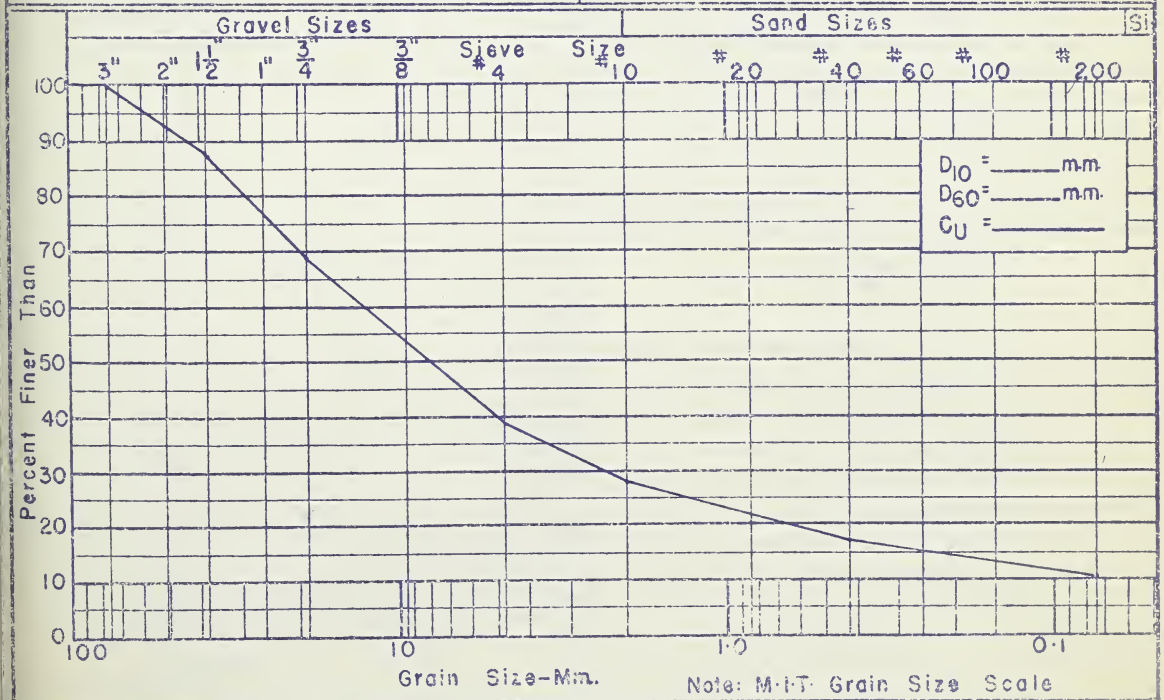
SIEVE ANALYSIS

PROJECT
SITE
SAMPLE 21475
LOCATION CRAWFORD PIT
HOLE DEPTH
TECHNICIAN DATE APRIL 28/58

Total Dry Weight of Sample	Sieve No.	Size of Opening Inches	Size of Opening Mm.	Weight Retained gms.	Total Wt. Finer Than gms.	Percent Finer Than	% Finer Than Basis Orig. Sample
Initial Dry Weight Retained No. 4							
Tare No.		3				100	
Wt. Dry + Tare		1½				88	
Tare		¾	19·10			69	
Wt. Dry		⅜	9·52				
	4	·185	4·76				
Passing	4					39	
Initial Dry Weight Passing No. 4							
Tare No.	10	·079	2·000			28	
Wt. Dry + Tare	20	·0331	·840				
Tare	40	·0165	·420			17	
Wt. Dry	60	·0097	·250				
	100	·0059	·149				
	200	·0029	·074				
Passing	200					10.2	

Description of Sample
% overage = 14
Time of Sieving

Method of Preparation -air dried and overage removed.
Remarks



TEST #1

62

UNIVERSITY of ALBERTA
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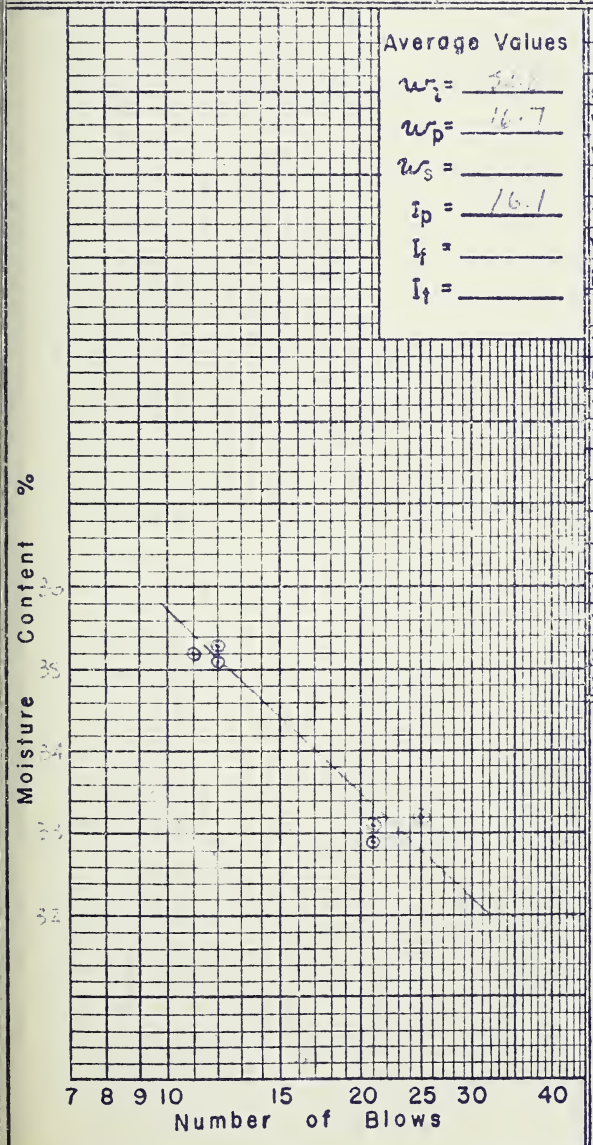
SOIL MECHANICS LABORATORY
ATTERBERG LIMITS

PROJECT	
SITE	
SAMPLE	#40 CRAWFORD PIT VIAIL.
LOCATION	
HOLE	DEPTH
TECHNICIAN	DATE

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	21	25	21	17	12	10
Container No.	V67	166	62			
Wt. Sample Wet + Tare	77.500	79.742	78.523	78.[illegible]	81.962	
Wt. Sample Dry + Tare	75.358	76.047	75.195	75.9[illegible]	79.021	
Wt. Water	2.142	3.695	3.328	[illegible]	2.941	
Tare Container	68.980	66.408	66.794	69.[illegible]	71.[illegible]	
Wt. of Dry Soil	6.378	9.639	8.401	[illegible]	7.119	
Moisture Content w%	33.1	33.1	33.9	35.[illegible]	35.3	



Average Values

w_i = 34.1

w_p = 16.7

w_s = _____

I_p = 16.1

I_f = _____

I_t = _____

Plastic Limit

Trial No.	1		
Container No.	[illegible]		[illegible]
Wt. Sample Wet+Tare	[illegible]	[illegible]	[illegible]
Wt. Sample Dry+Tare	[illegible]	[illegible]	[illegible]
Wt. Water	[illegible]	[illegible]	[illegible]
Tare Container	[illegible]	[illegible]	[illegible]
Wt. of Dry Soil	[illegible]	[illegible]	[illegible]
Moisture Content %	[illegible]	16.7	[illegible]

16.7 [illegible]

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: _____

[illegible]

Remarks: _____

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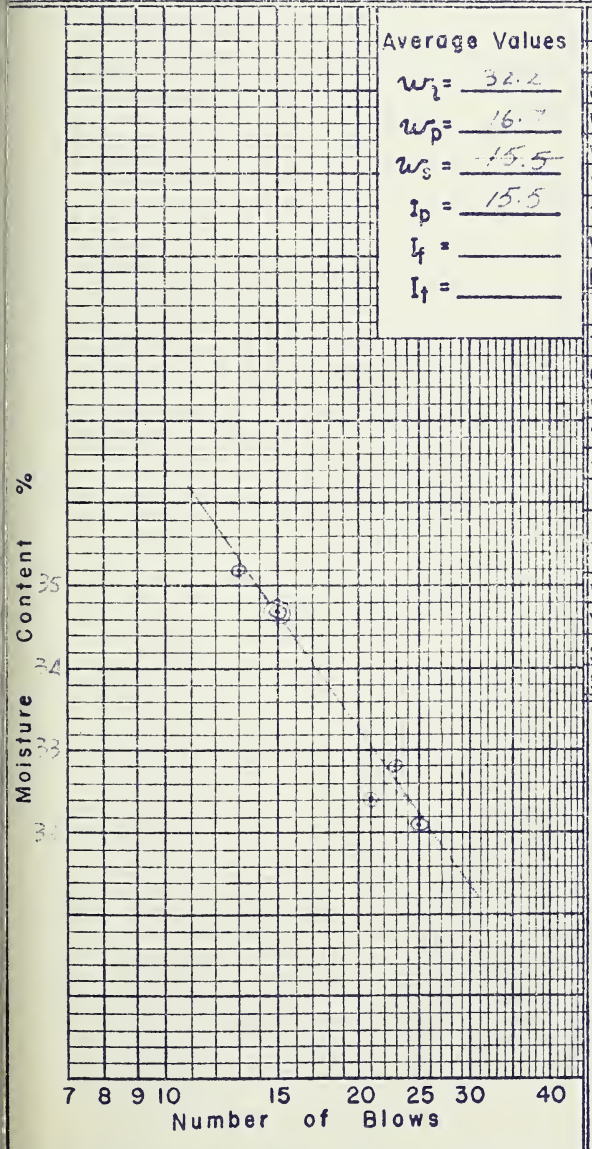
SOIL MECHANICS LABORATORY
ATTERBERG LIMITS

PROJECT	
SITE	
SAMPLE	#40 CRAWFORD PIT MATL.
LOCATION	
HOLE	DEPTH
TECHNICIAN	DATE MAY 21/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	23	25	21	15	13	12
Container No.	Y5	Y4	Y3	Y12	Y8	V
Wt. Sample Wet + Tare	74.9786	74.5993	73.1542	86.2880	84.5181	79.88
Wt. Sample Dry + Tare	72.5763	71.7844	70.3113	83.8048	81.5227	76.6386
Wt. Water	2.4023	2.8149	2.8429	2.4832	2.9954	3.2414
Tare Container	63.9[illegible]2	63.0048	61.[illegible]07	76.65[illegible]6	72.88[illegible]8	69.[illegible]2
Wt. of Dry Soil	8.[illegible]471	8.[illegible]796	8.[illegible]486	7.[illegible]152	8.[illegible]539	7.[illegible]638
Moisture Content w%	[illegible]	[illegible]	[illegible]	34.1	36.1	[illegible]



Average Values

w_l = 32.2

w_p = 16.7

w_s = 15.5

I_p = 15.5

I_f = _____

I_t = _____

Plastic Limit

Trial No.			
Container No.	[illegible]	[illegible]	[illegible]
Wt. Sample Wet+Tare	[illegible]	[illegible]	[illegible]
Wt. Sample Dry+Tare	[illegible]	67.0150	[illegible]
Wt. Water	0.1799	[illegible]	0.[illegible]
Tare Container	[illegible]	61.5407	[illegible]
Wt. of Dry Soil	[illegible]	[illegible]	[illegible]
Moisture Content %	[illegible]	[illegible]	[illegible]

16.7 Ave

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: _____

Inorganic clay and some fine to medium sand

Remarks: _____

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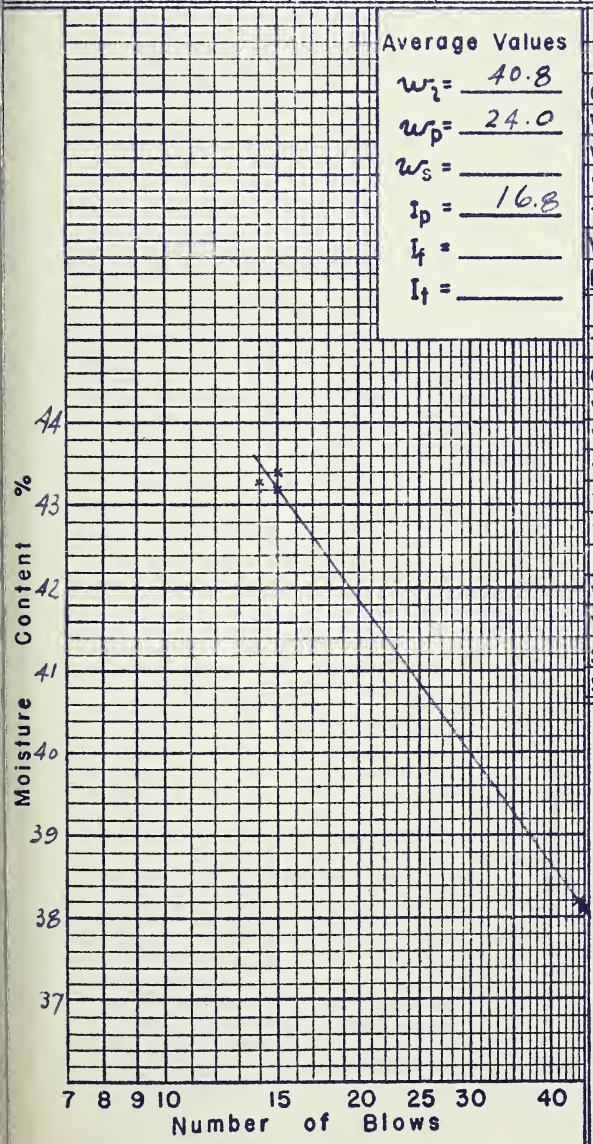
SOIL MECHANICS LABORATORY
ATTERBERG LIMITS

PROJECT
SITE
SAMPLE -#40 CRAWFORD PIT MATL.
LOCATION
HOLE DEPTH
TECHNICIAN DATE JULY 28/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	44	45	45	15	14	15
Container No.	V-4	V-5	V-6	V-7	V-8	V-9
Wt. Sample Wet + Tare	72.9292	74.5426	85.9874	78.1478	72.8622	89.4507
Wt. Sample Dry + Tare	70.1885	71.9754	83.4366	75.4161	69.8425	86.4836
Wt. Water	2.7407	2.5672	2.5508	2.7317	3.0197	2.9671
Tare Container	63.0010	65.2293	76.7362	69.1276	62.8784	79.5444
Wt. of Dry Soil	7.1875	6.7461	6.7004	6.2885	6.9641	6.9192
Moisture Content w%	38.2	38.1	38.1	43.4	43.3	43.2



Average Values
w_i = 40.8
w_p = 24.0
w_s = ____
I_p = 16.8
I_f = ____
I_t = ____

Plastic Limit

Trial No.	1	2	3
Container No.	V-18	V-19	V-20
Wt. Sample Wet+Tare	74.5742	80.5957	68.1058
Wt. Sample Dry+Tare	73.9335	79.7103	67.5994
Wt. Water	0.6407	0.8854	0.5064
Tare Container	71.3359	75.7673	65.5711
Wt. of Dry Soil	2.5976	3.9430	2.0283
Moisture Content %	24.7	22.5	24.9

(24.0 ave.)

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w\left(\frac{V-V_o}{W_o} \times 100\right)$$

Description of Sample: Inorganic clay of low to medium plasticity.

Remarks:

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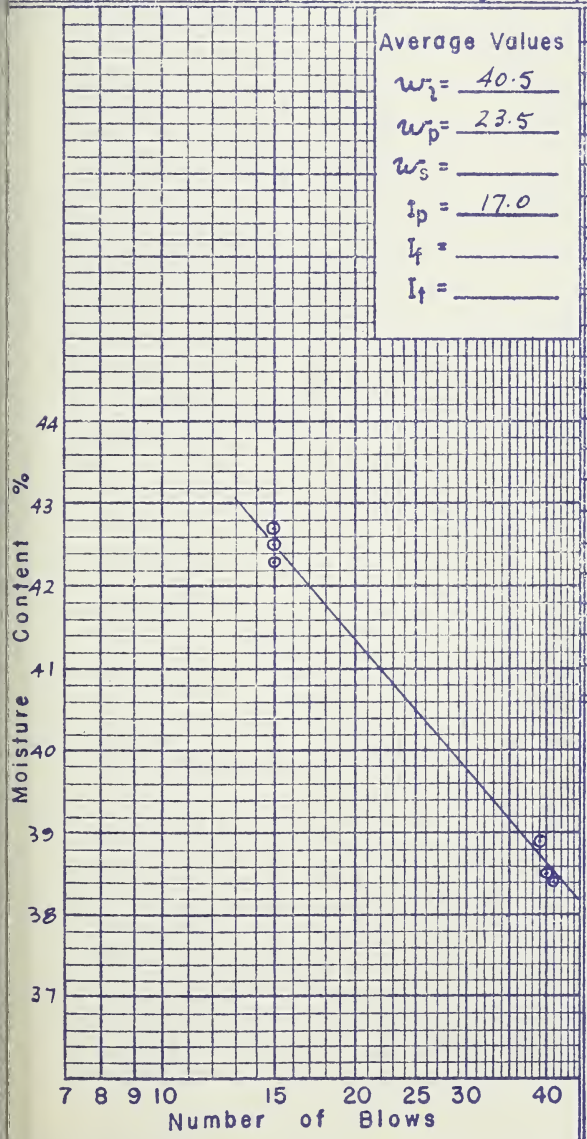
ATTERBERG LIMITS

PROJECT	
SITE	
SAMPLE	-#40 MATL. - CRAWFORD PIT
LOCATION	
HOLE	DEPTH
TECHNICIAN	DATE AUG 15/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	39	40	41	15	15	15
Container No.	V14	V15	V16	V17	V20	V21
Wt. Sample Wet + Tare	78.628	72.425	69.099	93.282	73.835	85.623
Wt. Sample Dry + Tare	75.047	69.769	66.747	90.122	71.372	81.785
Wt. Water	3.581	2.656	2.352	3.160	2.463	3.838
Tare Container	65.838	62.871	60.620	82.648	65.571	72.810
Wt. of Dry Soil	9.209	6.898	6.127	7.474	5.801	8.975
Moisture Content w%	38.9	38.5	38.4	42.3	42.5	42.7



Average Values

w_l = 40.5

w_p = 23.5

w_s = _____

I_p = 17.0

I_f = _____

I_t = _____

Plastic Limit

Trial No.	1	2	3	
Container No.	V24	V25	V26	
Wt. Sample Wet+Tare	84.807	90.140	78.971	
Wt. Sample Dry+Tare	83.507	89.132	77.918	
Wt. Water	1.300	1.008	1.053	
Tare Container	77.880	84.878	73.514	
Wt. of Dry Soil	5.627	4.254	4.404	
Moisture Content %	23.1	23.6	23.9	23.5 (ave.)

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: _____

Sample allowed to soak 1 day at moisture content near (higher) than liquid limit.

Remarks: _____

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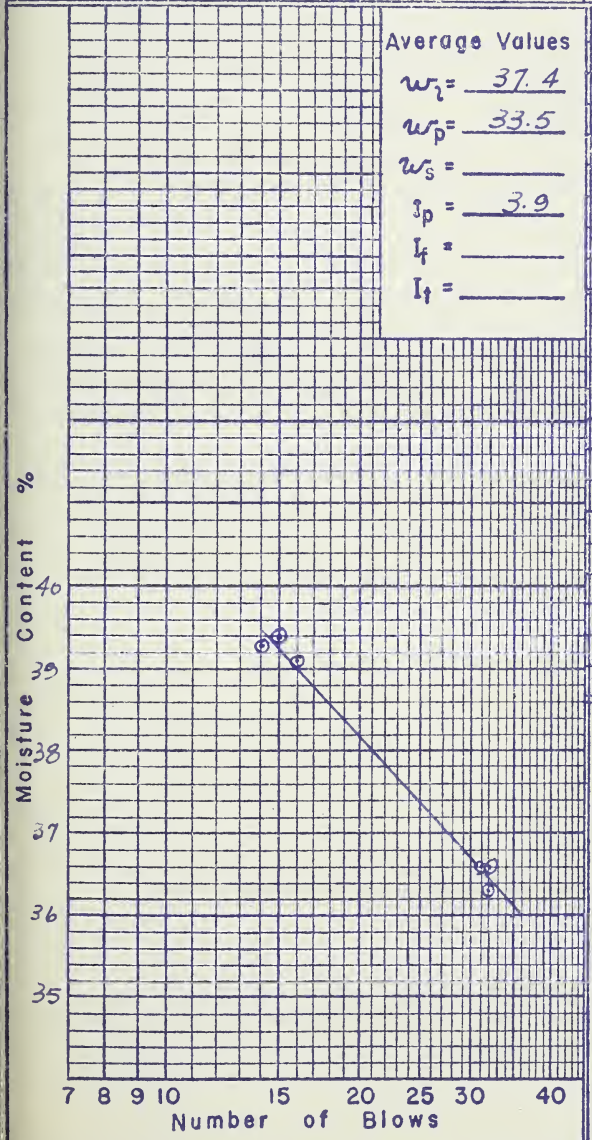
ATTERBERG LIMITS

PROJECT
SITE
SAMPLE 3.5% QUICKLIME + 7% FLY ASH
LOCATION BY WEIGHT OF CRANFORD - #40
HOLE DEPTH
TECHNICIAN DATE AUG 19/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	32	31	32	15	16	14
Container No.	A6	A7	A8	A5	V9	A10
Wt. Sample Wet + Tare	75.015	83.395	77.148	79.299	91.234	99.689
Wt. Sample Dry + Tare	71.921	78.952	73.471	75.582	87.948	94.817
Wt. Water	3.094	4.443	3.677	3.617	3.286	4.872
Tare Container	63.398	66.786	63.439	66.149	79.548	82.423
Wt. of Dry Soil	8.523	12.166	10.032	9.433	8.460	12.394
Moisture Content w%	36.3	36.6	36.6	39.4	39.1	39.3



Average Values

w_l = 37.4
w_p = 33.5
w_s = ____
I_p = 3.9
I_f = ____
I_t = ____

Plastic Limit

Trial No.	1	2	3
Container No.	A16	A17	V18
Wt. Sample Wet+Tare	77.500	72.768	77.513
Wt. Sample Dry+Tare	75.757	71.416	75.987
Wt. Water	1.743	1.352	1.526
Tare Container	70.635	67.389	71.336
Wt. of Dry Soil	5.122	4.027	4.651
Moisture Content %	34.0	33.7	32.8

33.5 (ave)

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: ____

Remarks: The sample was mixed and allowed to stand in the moist room 24 hrs. before test.

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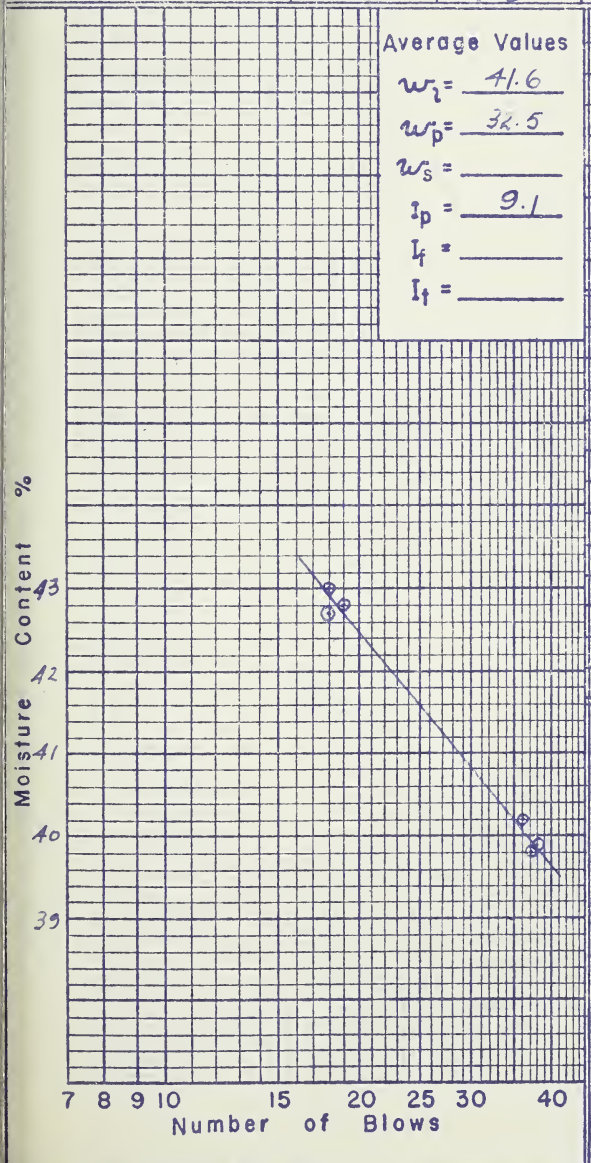
SOIL MECHANICS LABORATORY
ATTERBERG LIMITS

PROJECT	
SITE	HIGH EARLY CEMENT,
SAMPLE	5% BY WEIGHT OF
LOCATION	CRAWFORD — #40 MATL.
HOLE	DEPTH
TECHNICIAN	DATE AUG 22/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	38	37	36	19	18	18
Container No.	A6	A7	A8	V21	V24	V26
Wt. Sample Wet + Tare	80.408	81.213	75.593	83.488	90.116	86.367
Wt. Sample Dry + Tare	75.554	77.103	72.070	80.292	86.452	82.503
Wt. Water	4.854	4.110	3.530	3.196	3.664	3.864
Tare Container	63.398	66.786	63.310	72.813	77.881	73.513
Wt. of Dry Soil	12.156	10.317	8.760	7.479	8.571	8.990
Moisture Content w%	39.9	39.8	40.2	42.8	42.7	43.0



Average Values

w_l = 41.6

w_p = 32.5

w_s = _____

I_p = 9.1

I_f = _____

I_t = _____

Plastic Limit

Trial No.	1	2	3
Container No.	V19	V73	V7
Wt. Sample Wet+Tare	85.827	73.371	75.396
Wt. Sample Dry+Tare	83.326	71.622	73.880
Wt. Water	2.501	1.749	1.516
Tare Container	75.768	66.259	69.120
Wt. of Dry Soil	7.558	5.363	4.750
Moisture Content %	33.1	32.6	31.9

32.5 (Ave.)

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: _____

Remarks: The sample was mixed and allowed to stand in the moist room 3 hrs. before test.

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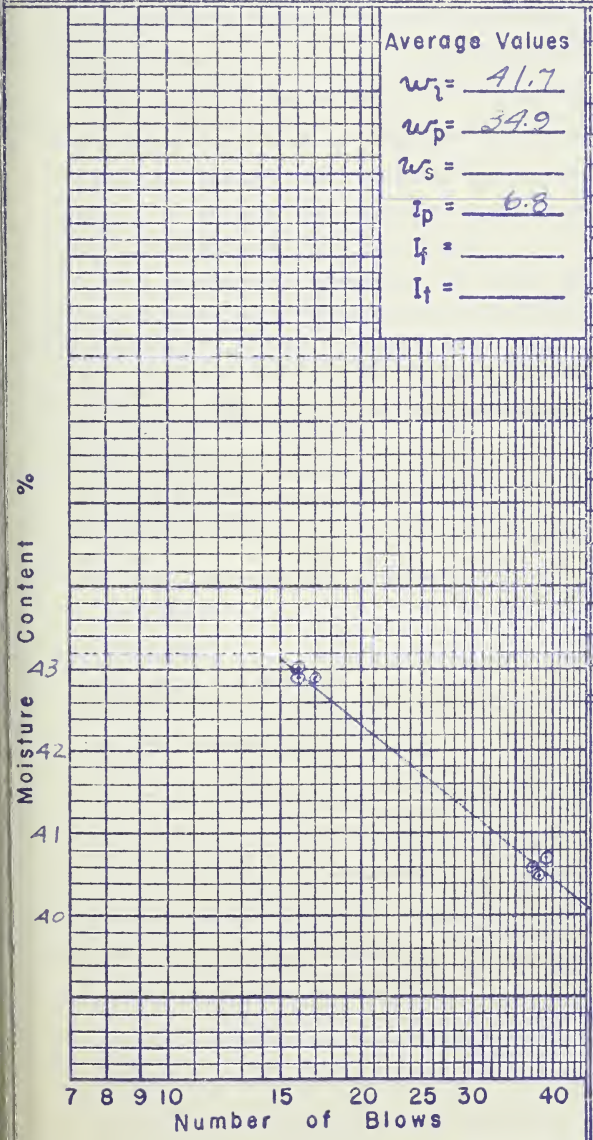
SOIL MECHANICS LABORATORY
ATTERBERG LIMITS

PROJECT
SITE HIGH EARLY CEMENT
SAMPLE 5% BY WEIGHT OF
LOCATION CRAWFORD - #40 MATL.
HOLE DEPTH
TECHNICIAN DATE AUG 22/58

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	38	39	37	16	17	16
Container No.	V64	V63	V62	A3	A2	A1
Wt. Sample Wet + Tare	79.023	80.253	74.847	81.880	78.517	74.565
Wt. Sample Dry + Tare	75.493	76.250	72.011	78.853	75.500	71.285
Wt. Water	3.530	4.003	2.836	3.027	3.017	3.280
Tare Container	66.774	66.407	65.029	71.812	68.475	63.638
Wt. of Dry Soil	8.719	9.843	6.982	7.041	7.025	7.647
Moisture Content w%	40.5	40.7	40.6	43.0	42.9	42.9



Average Values
w_l = 41.7
w_p = 34.9
w_s = ____
I_p = 6.8
I_f = ____
I_t = ____

Plastic Limit

Trial No.	1	2	3	
Container No.	V70	V69	A25	
Wt. Sample Wet + Tare	89.788	79.472	73.854	
Wt. Sample Dry + Tare	87.799	76.851	71.920	
Wt. Water	1.989	2.621	1.934	
Tare Container	82.157	69.387	66.295	
Wt. of Dry Soil	5.642	7.464	5.625	
Moisture Content %	35.3	35.1	34.4	34.9 (ave.)

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V - V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V - V_o}{W_o} \times 100\right)$$

Description of Sample: ____

Remarks: The sample was mixed and allowed to stand in the moist room 7 hrs before test.

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SPECIFIC GRAVITY

PROJECT	
SITE	
SAMPLE	CRAWFORD GRAVEL
LOCATION	
HOLE	DEPTH
TECHNICIAN	DATE MAY 26/58

Sample No.	① - Minus #4 MATL.	SAMPLE MADE UP AS
Flask No.	5	FOLLOWS: (-#4)
Method of Air Removal	VACUUM	-#4 + #10 = 37.5 gms
W_{b+w+s}	1015.	#10 + #40 = 37.5 gms
Temperature T		-#40 = 25.0 gms
W_{b+w}	639.7	
Evaporating Dish No.	B-2	(+#4) MATL.
Wt. Sample Dry + Dish	1005.41	-3" + 1/4" = 2250 gms
Tare Dish	967.10	-1/4" + #4 = 750 gms
W_s	38.31	5000 gms
G_s	2.69	

W_{b+w+s} = Weight of flask + water + sample at T°.
W_{b+w} = Weight of flask + water at T° (flask calibration curve).
W_s = Weight of dry soil
G_s = Specific gravity of soil particles = $\frac{W_s}{W_s + W_{b+w} - W_{b+w+s}}$

Determination of W_s from wet soil sample:

Sample No.			Sample No.		
Container No.			Container No.		
Wt. Sample Wet + Tare			Wt. Test Sample Wet + Tare		
Wt. Sample Dry + Tare			Tare Container		
Wt. Water			Wt. Test Sample Wet		
Tare Container			W_s		
Wt. of Dry Soil					
Moisture Content w %					

Description of Sample: ② - Plus #4 Matl.
Wt. of oven-dry aggregate in air + basket = 4042 gms.
Wt. of basket in air = 735 "
" " " " water = 450 "
Wt of aggregate + basket in water = 2858 "
Remarks: Sp. gr. of +#4 matl. = $\frac{4212}{1577}$ = 2.67

Average Sp. gr. of total sample = 60%(2.67) + 40%(2.69)
= 1.60 + 1.08
= 2.68

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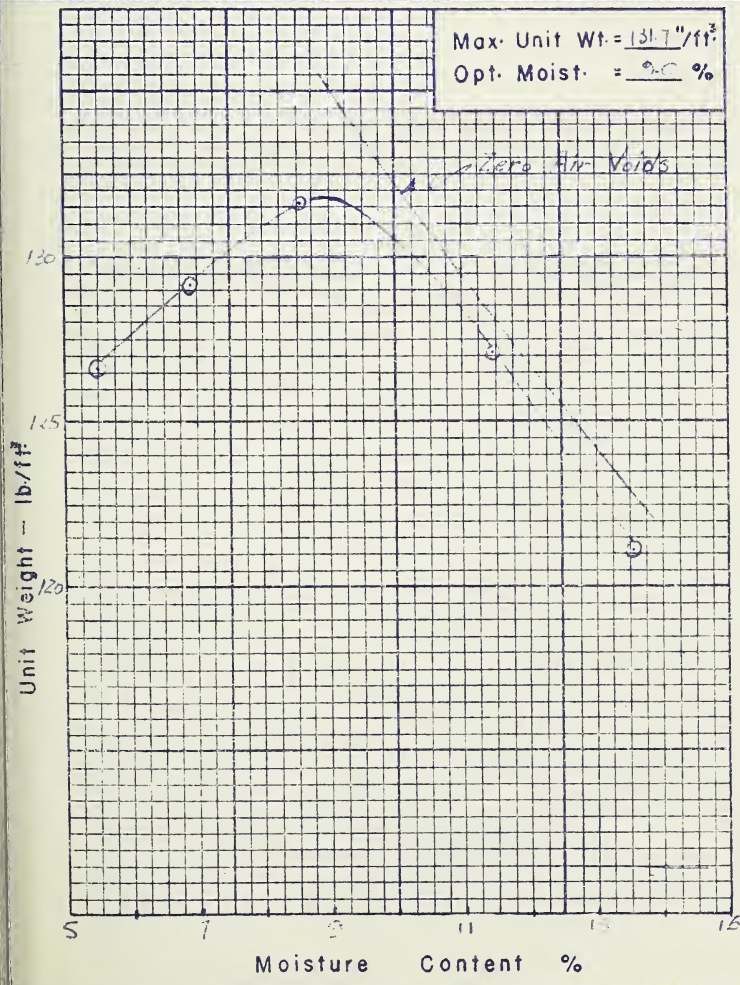
SOIL MECHANICS LABORATORY
COMPACTION TEST

PROJECT
SITE
SAMPLE - #4 CRAWFORD PIT MATL.
LOCATION
HOLE DEPTH
TECHNICIAN DATE

Trial Number		1	2	3	4	5		
Unit Weight Determination	Mold No.	4	4	4	4	4		
	Wt. Sample Wet + Mold	3915	3895	3828	3770	3840		
	Wt. Mold	1743	1743	1743	1743	1743		
	Wt. Sample Wet	2169	2152	2085	2027	2097		
	Volume Mold	947	947	947	947	947		
	Wet Unit Weight lb./ft.^{3}	142.8	141.7	137.4	133.6	138.0		
	Dry Unit Weight lb./ft.^{3}	131.6	130.1	126.1	126.6	129.6		
Moisture Content Determination	Container No.	5	6	7	8	9		
	Wt. Sample Wet + Tare	142.15	134.20	133.90	134.96	134.30		
	Wt. Sample Dry + Tare	138.21	114.23	104.08	128.98	128.11		
	Wt. Water	3.94	3.97	9.91	5.98	6.19		
	Tare Container	30.33	36.41	31.14	30.12	28.61		
	Wt. Dry Soil	107.88	77.82	72.94	108.86	99.50		
	Moisture Content	3.6	4.4	13.6	5.5	6.2		



Method of Compaction MODIFIED PROCTOR

Diam. Mold 4 4/16"
Height Mold 4 9/16"
Volume Mold 947 cc.
No. of Layers 5
Blows per Layer 25
Ht. of Free Fall 18"
Wt. of Tamper 10 lbs.
Shape of Tamping Face [illegible]
Description of Sample

Remarks Volume of mold determined by filling with water
Trials 1 & 5 were very hard.

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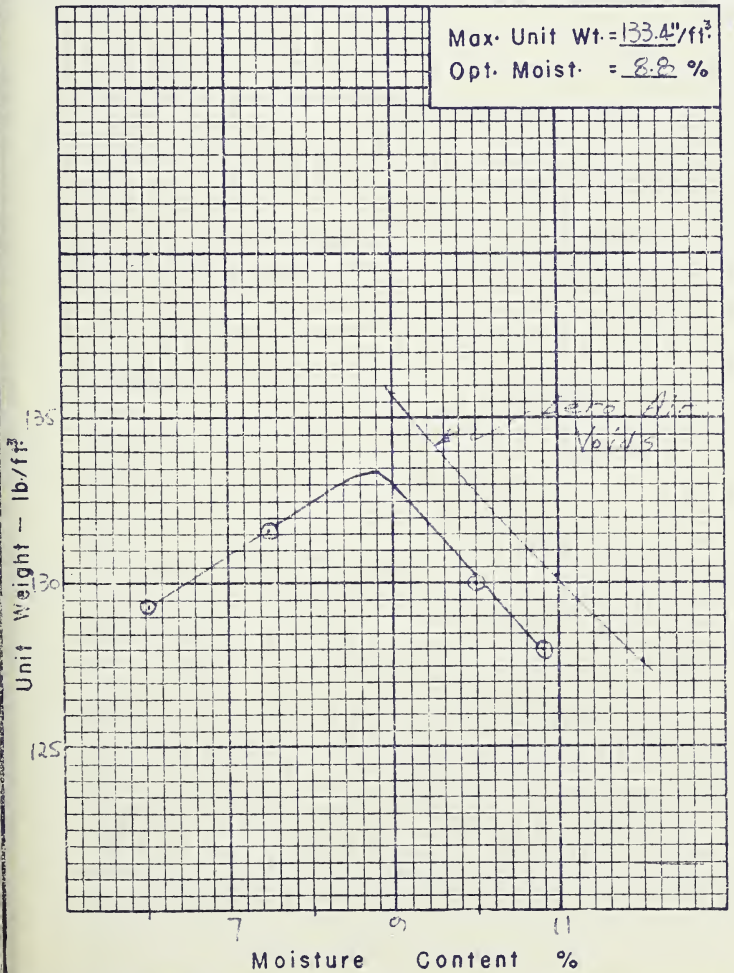
COMPACTION TEST

PROJECT
SITE
SAMPLE #4 CRAWFORD PIT MATL. + 5% CEMENT
LOCATION
HOLE DEPTH
TECHNICIAN DATE

	Trial Number	1	2	3	4			
Unit Weight Determination	Mold No.	4	4	4	4			
	Wt. Sample Wet + Mold	3822	3888	3912	3898			
	Wt. Mold	1743	1743	1743	1743			
	Wt. Sample Wet	2079	2145	2169	2155			
	Volume Mold	947	947	947	947			
	Wet Unit Weight lb./ft.^{3}	136.9	141.3	142.9	141.9			
	Dry Unit Weight lb./ft.^{3}	129.3	131.6	130.0	128.0			
Moisture Content Determination	Container No.	8	9	10	7			
	Wt. Sample Wet + Tare	119.62	122.41	127.99	135.12			
	Wt. Sample Dry + Tare	114.13	120.86	119.03	124.97			
	Wt. Water	5.09	6.55	8.96	10.15			
	Tare Container	28.53	28.61	29.43	31.04			
	Wt. Dry Soil	84.60	92.25	89.60	93.93			
	Moisture Content	6.04	7.5	10.00	10.80			



Method of Compaction MODIFIED PROCTOR

Diam. Mold
Height Mold
Volume Mold 947 cc
No. of Layers 5
Blows per Layer 25
Ht. of Free Fall 18"
Wt. of Tamper 10 lbs.
Shape of Tamping Face 2" ø
Description of Sample
-#4 + #10 = 938 gm
-#10 + #40 = 688 gm
-#40 = 874 gm
2500 gm
Hyd. w/c = 1.5
Dry wt. of sample = 2460
5% Cement added = 123
Total wt. = 2583

Remarks

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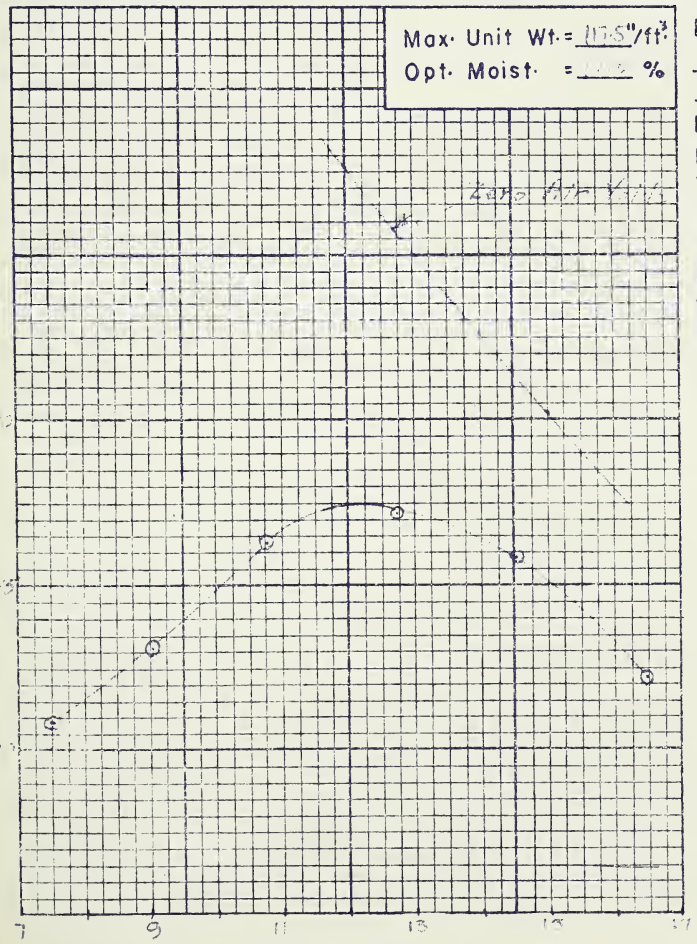
COMPACTION TEST

PROJECT
SITE
SAMPLE – #4 CRUSHED HT MATL. + 5% CEMENT.
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 18/58

Trial Number		1	2	3	4	5	6	
Unit Weight Determination	Mold No.	3	4	5	6	7	8	
	Wt. Sample Wet + Mold	13.84	14.18	14.97	15.45	15.21	15.01	
	Wt. Mold	7.49	7.49	7.49	7.49	7.49	7.49	
	Wt. Sample Wet	6.35	6.69	7.48	7.96	7.72	7.52	
	Volume Mold	0.0497	0.0497	0.0497	0.0497	0.0497	0.0497	
	Wet Unit Weight lb./ft.^{3}	119.0	123.5	128.8	132.0	132.8	130.6	
	Dry Unit Weight lb./ft.^{3}	110.9	113.1	116.3	117.2	115.9	112.2	
Moisture Content Determination	Container No.	5	6	7	8	9	10	
	Wt. Sample Wet + Tare	146.0674	144.2138	155.0256	140.1339	150.9304	163.5128	
	Wt. Sample Dry + Tare	137.9816	134.3583	142.9360	127.7216	135.4048	144.5843	
	Wt. Water	8.0858	9.8555	12.0896	12.4123	15.5256	18.9285	
	Tare Container	30.32	26.41	31.04	29.13	28.64	29.425	
	Wt. Dry Soil	107.65	107.95	111.90	98.59	106.79	115.16	
	Moisture Content	7.53	9.14	10.80	12.72	14.58	16.43	

Max. Unit Wt. = 133.5 lb./ft.^{3}
Opt. Moist. = 11.2 %



Method of Compaction STD. PROCTOR HAMMER – 3 LIFTS 12-17-12 BLOWS (½ STD. PROCTOR COMPACTION)
Diam. Mold 4" (APPROX. INSIDE)
Height Mold
Volume Mold 0.0497 cu. ft.
No. of Layers 3
Blows per Layer 12 – 17 – 12
Ht. of Free Fall 12"
Wt. of Tamper 5.5 lb.
Shape of Tamping Face 2" ø
Description of Sample

#4 + 3/8" = 9.8 %
3/8" + #4 = 6.8 %
#4 = 5.1 %
PASSING = 1.1 %

Remarks

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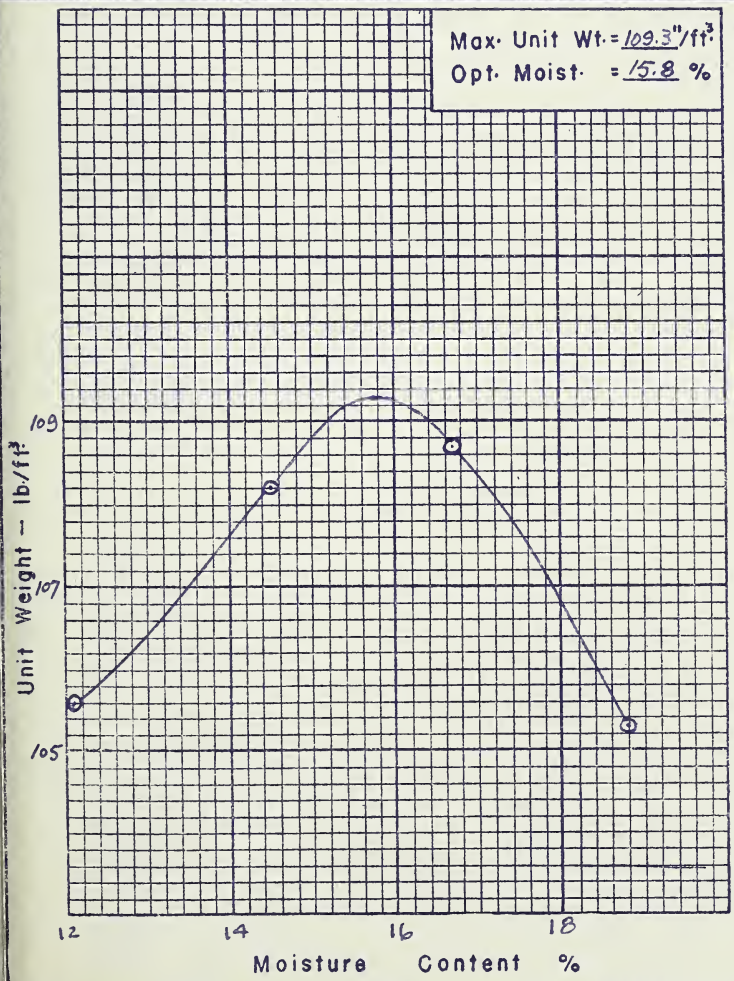
COMPACTION TEST

PROJECT
SITE
SAMPLE - #4 MATL. - CRAWFORD PIT
LOCATION PLUS 3.5% LIME PLUS 7% FLYASH DEPTH
HOLE
TECHNICIAN JC DATE AUG 1/58

	Trial Number	1	2	3	4			
Unit Weight Determination	Mold No.	4	4	4	4			
	Wt. Sample Wet + Mold	3536	3625	3669	3643			
	Wt. Mold	1743	1743	1743	1743			
	Wt. Sample Wet	1793	1882	1926	1900			
	Volume Mold	947	947	947	947			
	Wet Unit Weight lb./ft.^{3}	118.1	124.0	126.8	125.1			
	Dry Unit Weight lb./ft.^{3}	105.6	108.4	108.7	105.3			
Moisture Content Determination	Container No.	9	10	11	12			
	Wt. Sample Wet + Tare	131.13	116.80	127.74	149.06			
	Wt. Sample Dry + Tare	120.15	105.77	115.30	131.79			
	Wt. Water	10.98	11.03	12.44	17.27			
	Tare Container	29.53	29.54	40.63	40.01			
	Wt. Dry Soil	90.62	76.23	74.67	91.78			
	Moisture Content	12.10	14.48	16.67	18.80			



Method of Compaction
½ STD. PROCTOR
12 - 12 - 13 BLOWS
Diam. Mold
Height Mold
Volume Mold
No. of Layers 3
Blows per Layer 12 - 12 - 13
Ht. of Free Fall 12"
Wt. of Tamper 5.5 lbs
Shape of Tamping Face 2"ø
Description of Sample
938 gms. of -#4 + #10 MATL.
688 " " -#10 + #40 "
874 " " -#40 "
87.5 " " LIME (QUICK)
175 " " FLYASH

Remarks

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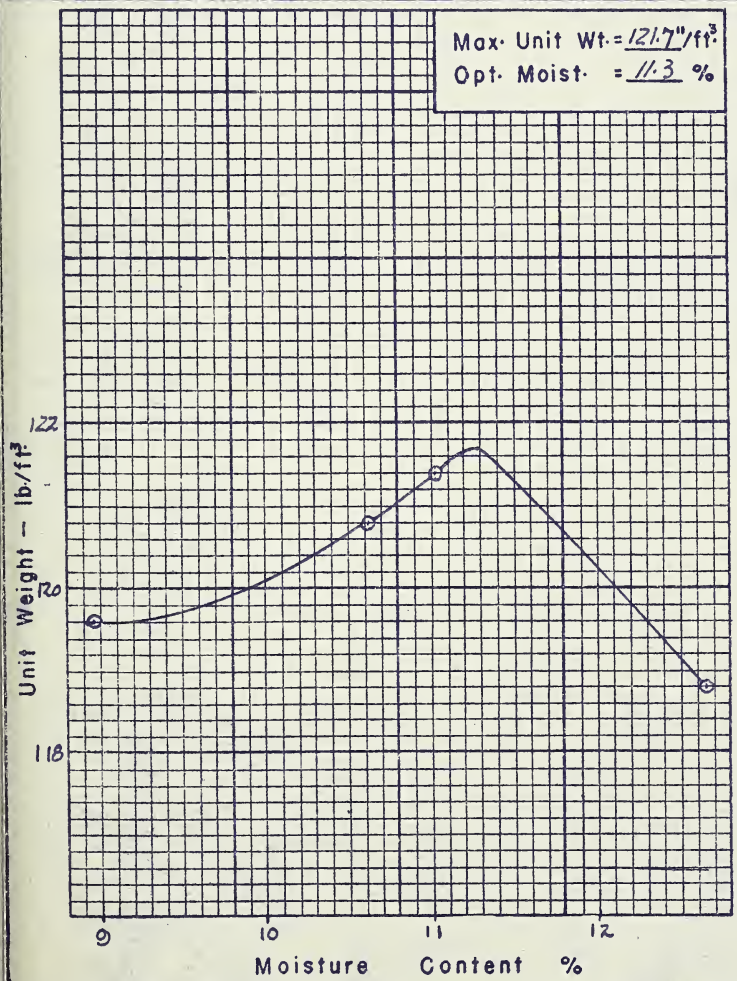
SOIL MECHANICS LABORATORY
COMPACTION TEST

PROJECT
SITE
SAMPLE -#4 MATL. CRAWFORD PIT
LOCATION PLUS 3.5% LIME PLUS 7%
HOLE FLYASH DEPTH
TECHNICIAN JSC DATE AUG 1/58

	Trial Number	1	2	3	4			
Unit Weight Determination	Mold No.	4	4	4	4			
	Wt. Sample Wet + Mold	3720	3768	3790	3770			
	Wt. Mold gm	1743	1743	1743	1743			
	Wt. Sample Wet gm.	1977	2025	2047	2027			
	Volume Mold ccs.	947	947	947	947			
	Wet Unit Weight lb./ft^3	130.2	133.4	134.8	133.6			
	Dry Unit Weight lb./ft^3	119.6	120.8	121.4	118.8			
Moisture Content Determination	Container No.	5	14	7	8			
	Wt. Sample Wet + Tare	149.57	130.73	138.15	123.41			
	Wt. Sample Dry + Tare	139.76	120.94	127.53	112.94			
	Wt. Water	9.81	9.79	10.62	10.47			
	Tare Container	30.33	28.73	31.04	30.13			
	Wt. Dry Soil	109.43	92.21	96.49	82.81			
	Moisture Content	8.96	10.62	11.02	12.65			



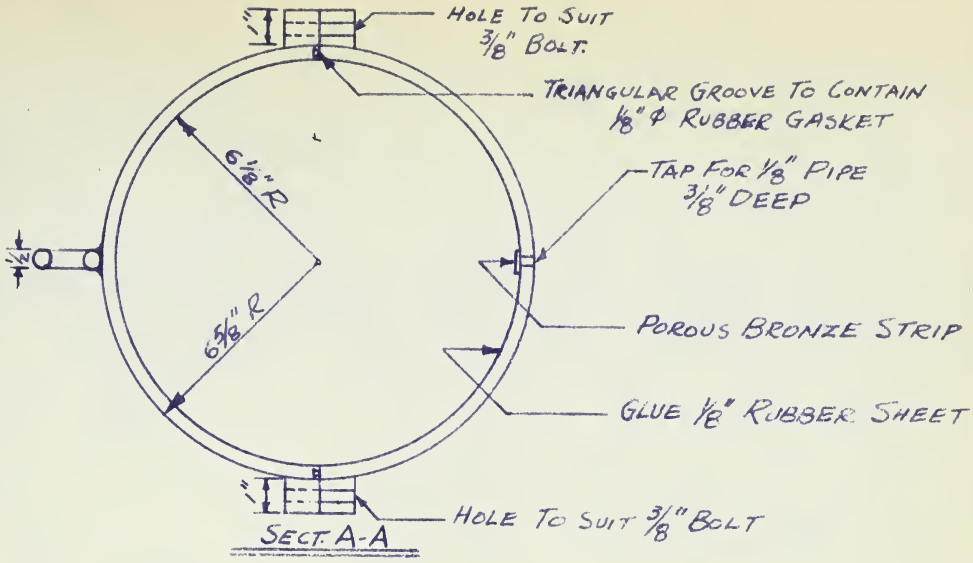
Method of Compaction MODIFIED PROCTOR

Diam. Mold
Height Mold
Volume Mold
No. of Layers 5
Blows per Layer 25
Ht. of Free Fall 18"
Wt. of Tamper 10 lbs
Shape of Tamping Face 0 2"ϕ
Description of Sample
938 gms of -#4+#10 MATL.
688 " " -#10+#40 "
874 " " -#40 "
87.5 " " QUICKLIME
175 " " FLYASH

Remarks

APPENDIX B

TRIAXIAL TEST DATA


HOLE TO SUIT 3/8" BOLT
TRIANGULAR GROOVE TO CONTAIN 1/8" ϕ RUBBER GASKET
TAP FOR 1/8" PIPE 3/8" DEEP
6 1/8" R
6 5/8" R
1 1/2"
POROUS BRONZE STRIP
GLUE 1/8" RUBBER SHEET
HOLE TO SUIT 3/8" BOLT
SECT. A-A

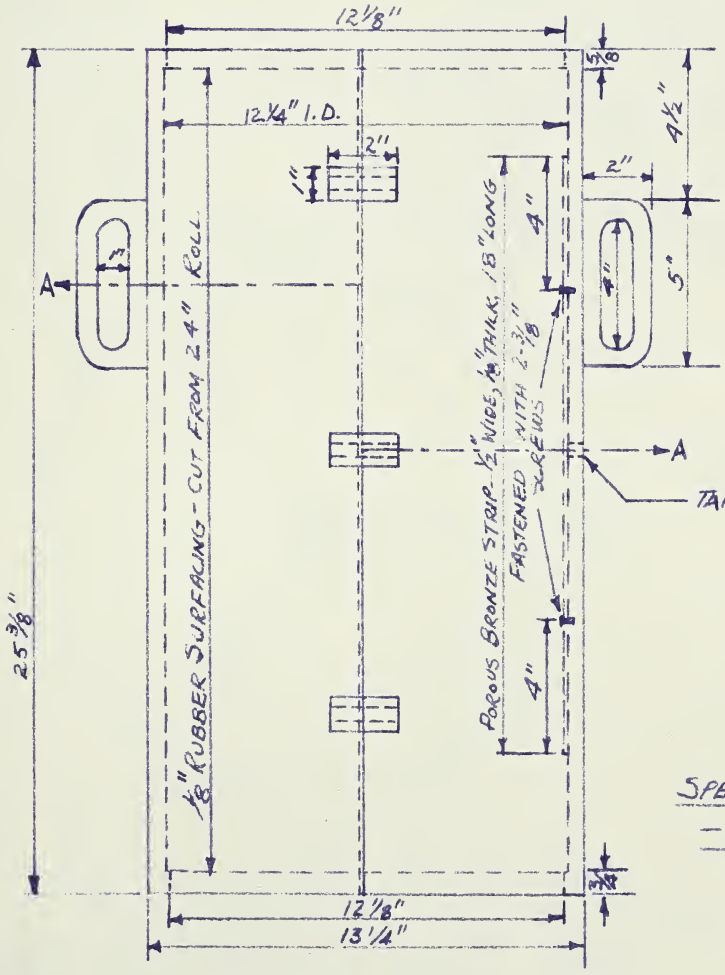


PLATE I

SPECIMEN FORMING MOLD

- CAST ALUMINUM -

Scale 1" = 5"

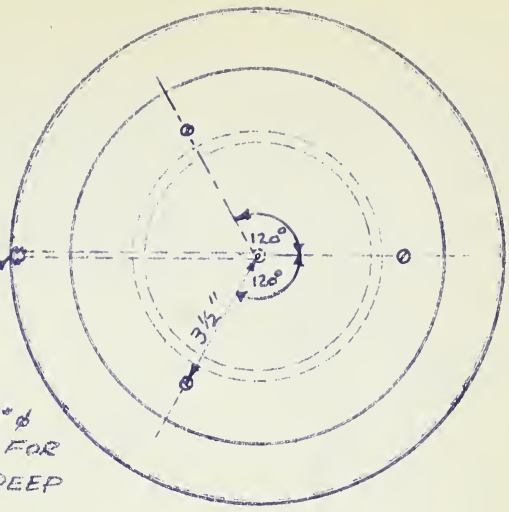
PLATE II

BASE AND TOP ℄s FOR VACUUM TRIAXIAL TESTING

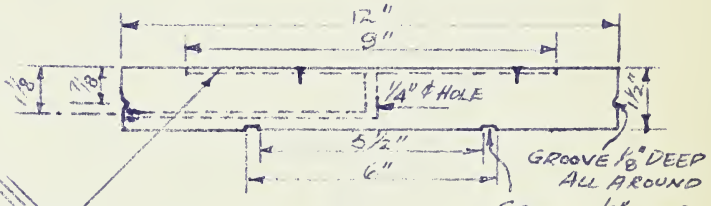
-CADMIUM PLATED STEEL-

Scale 1" = 4"

TOP ℄



DRILL ⅛" ϕ HOLE. TAP FOR ⅛" PIPE ⅜" DEEP

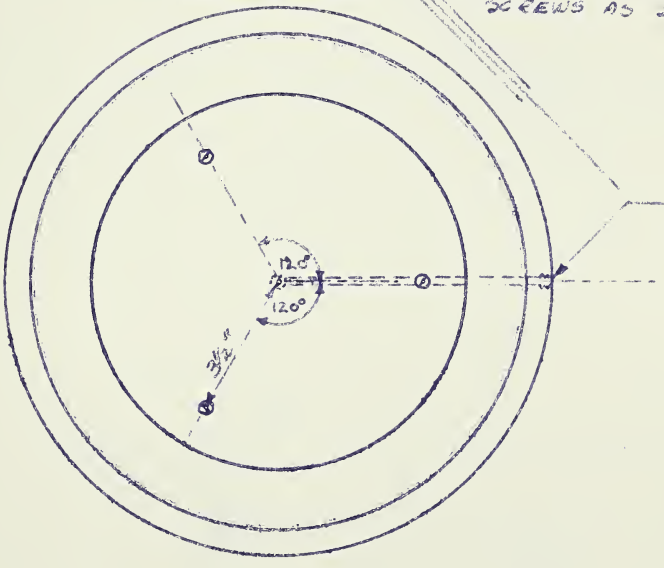


GROOVE ⅛" DEEP ALL AROUND

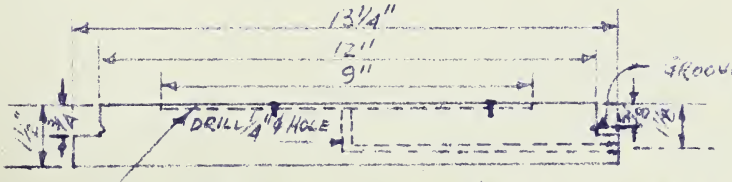
GROOVE ¼" WIDE, 1/16" DEEP.

9" ϕ POROUS BRONZE (⅛" THICK) FASTENED TO ℄ WITH 3-⅜" SCREWS AS SHOWN

BASE ℄

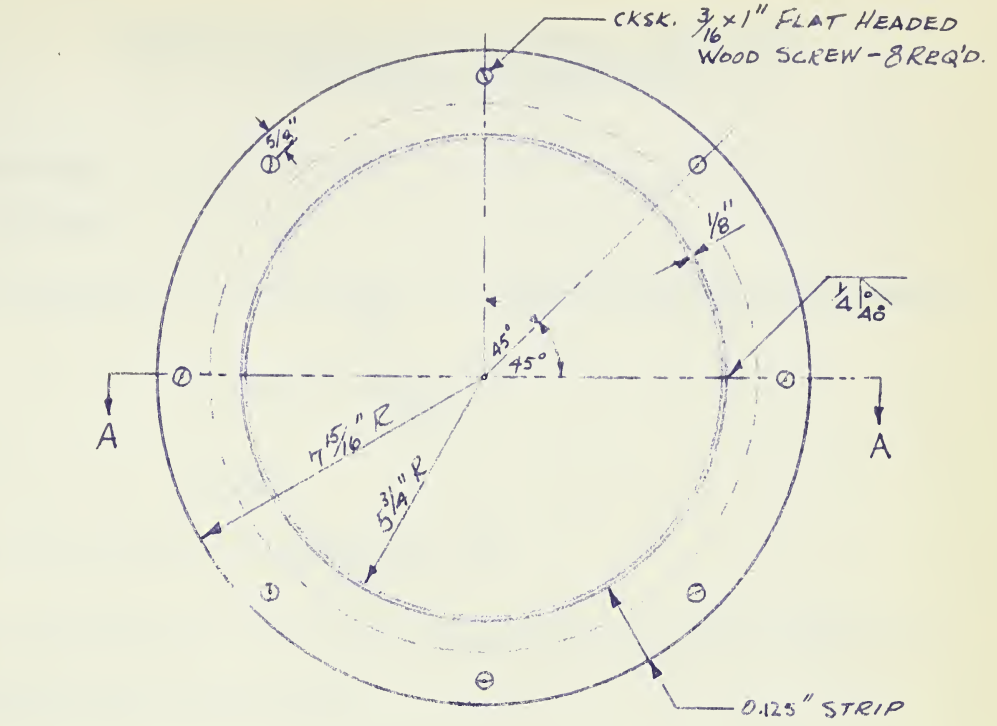


DRILL ⅛" ϕ HOLE. TAP FOR ⅛" PIPE ⅜" DEEP



GROOVE ⅛" DEEP ALL AROUND

9" ϕ POROUS BRONZE (⅛" THICK) FASTENED TO ℄ WITH 3-⅜" SCREWS AS SHOWN.



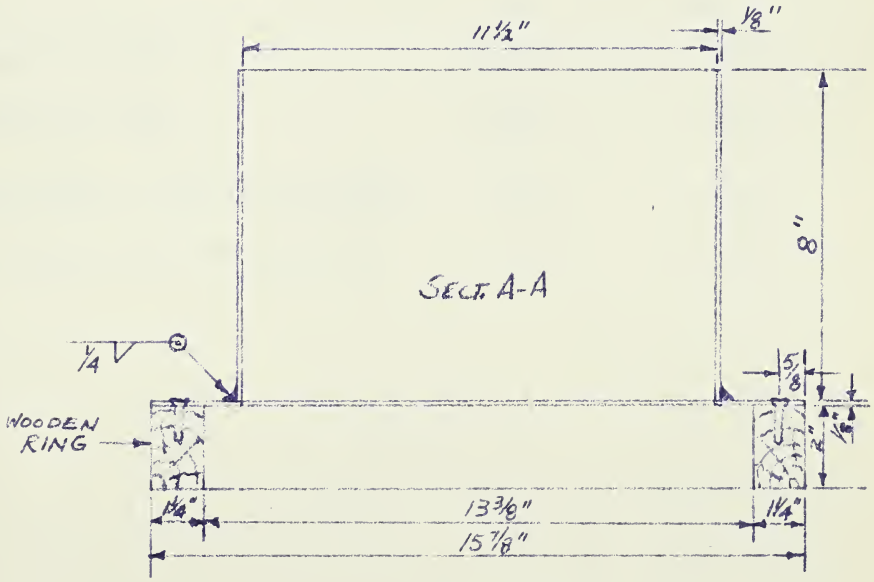


PLATE III

FORMING MOLD GUIDE SLEEVE

Scale 1" = 4"

DEGREE OF SATURATION AND INITIAL VOID RATIO FOR TYPICAL TEST SPECIMENS

Native Gravel

(Test #4)

Initial Void Ratio = $e = 1.0421\ G\ \frac{62.4}{121} - 1$ (where G = specific gravity of mixture)

$= 1.0421\ (2.68)\ \frac{62.4}{121} - 1$

$= 0.439$

Degree of Saturation = $S = \frac{0.0421\ (2.68)}{0.439} = 25\%$

These calculations were carried out for typical tests in the other test series run.

The values found are shown below.

	e	S
5% Cement (test #10)	0.370	38.3
2% Cement (test #30)	0.390	34.7
3.5% Quicklime - 7% Fly ash (test #20)	0.370	42.4
2% Quicklime - 4% Fly ash (test #25)	0.374	39.7

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #1
LOCATION
HOLE DEPTH
TECHNICIAN DATE MAY 29/56

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 kgm.

Description of Sample:
-3" [illegible] GRAVEL
6 LIFTS - MODIFIED PROCTOR HAMMER
55 BLOWS / LIFT

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		gtmos.	0.30					
Length		inches	24.0					
Area		sq. cms.	742.					
Volume		c.c.s. ft^3	1.595					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	115.0					
G_s= · Volume Soil Solids		γ_{moist}	120.0					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	13276					
Wt. Tare + Soil		"	12721					
Number and weight of Tare		"	837					
Wt. Soil		"	11884					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	555					
	Moisture content	%	4.66					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
gms.	ins	%	cm²	kg/cm²
0	0.9760	0	742.	0.34
200	.9760	0	742	.39
400	.9755	.002	742	.45
600	.9730	.0125	742	.50
800	.9705	.022	742	.56
1000	.9675	.035	742	.61
1200	.9635	.052	742	.66
1400	.9593	.070	742	.72
1600	.9540	.092	742	.77
1800	.9470	.121	743	.83
2000	.9370	.162	743	.88
2200	.9290	.196	744	.93
2400	.9173	.245	744	.99
2600	.9042	.30	744	1.04
2800	.8850	.38	745	1.09
3000	.8620	.475	745	1.14
3200	.8220	.64	747	1.20
3400	.7700	.86	749	1.25
3600	.7150	1.09	751	1.30
3800	.6290	1.45	753	1.35
4000	.5430	1.80	755	1.40
4200	.3900	2.44	760	1.44
4400	.1200	3.56	770	1.48
4500				1.50 ← FROM GRAPH

*FAILED - BULGING IN MIDDLE THIRD

Load on Pan	Dial Rdg.	Strain	Area	σ_1

Load on Pan	Dial Rdg.	Strain	Area	σ_1

REMARKS:

Density appears to be too low with this compactive effort - will use a higher compactive effort in further investigations

191.5# used in specimen

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PROJECT
SITE
SAMPLE TEST #2
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 4/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 kgm.

Description of Sample: - 3" CRAWFORD GRAVEL. 7 LIFTS 14 → 68 Blows/Lift (average of 56) - 25 ft-lb. blows per 3/8" lift (MODIFIED PROCTOR HAMMER)

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_3)	gt nos.	0.30					
Length	inches	24.0					
Area	sq. cms.	742.					
Volume	c.c.s. ft^3	1.595					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	118.5					
G_s= · Volume Soil Solids	γ_{moist}	122.6					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	22260					
Wt. Tare + Soil	"	21607					
Number and weight of Tare	"	2365					
Wt. Soil	"	19242					
Before Test: Weight of water							
Before Test: Moisture content							
Before Test: Degree of saturation							
After Test: Weight of water	"	653					
After Test: Moisture content	%	3.39					
After Test: Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
gms	"	%	cm^2	kg/cm^2										
0	0.997	0	742	.34										
300	.997	0	742	.42										
600	.993	.02	742	.50										
900	.988	.03	742	.58										
1200	.984	.05	742	.66										
1500	.978	.08	742	.74										
1800	.972	.10	743	.82										
2100	.966	.13	743	.91										
2400	.959	.16	743	.99										
2700	.953	.18	743	1.07										
3000	.946	.21	744	1.15										
3300	.939	.24	744	1.23										
3600	.932	.27	744	1.31										
3900	.925	.30	744	1.39										
4200	.915	.34	744	1.47										
4500	.903	.39	744	1.55										
4800	.888	.45	745	1.63										
5100	.871	.52	745	1.71										
5400	.849	.62	746	1.79										
5700	.812	.77	747	1.87										
6000	.755	1.01	749	1.94										
6200	.686	1.30	751	1.99										
6400	.629	1.53	754	2.04										
6600	.460	2.15	758	2.08										
6800				2.09	← FROM GRAPH									

REMARKS:

Sample appeared to be slightly on dry side for best compaction.

195.5# used in specimen.

FAILED - BULGING ABOUT MIDDLE OF SPECIMEN.

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #3
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 5/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 Kgm.

Description of Sample: -3" CRAWFORD GRAVEL - COMPACTED AS IN TEST #2.

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_3)		atmos.	0.30					
Length		inches	23.9					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.59					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	116.2					
G_s= · Volume Soil Solids		γ_{moist}	120.2					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	21995					
Wt. Tare + Soil		"	21313					
Number and weight of Tare		"	2393					
Wt. Soil		"	18920					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	682					
	Moisture content	%	3.61					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
gms	"	%	cm^2	Kgm/cm^2
0	0.992	0	742	0.34
300	.988			
600	.984	.03	742	.50
900	.978	.06	742	.58
1200	.973			
1500	.967	.10	742	.74
1800	.961			
2100	.956	.15	743	.91
3000	.935			
4000	.912	.34	744	1.42
4500	.899			
5000	.886	.44	745	1.68
5500	.871			
6000	.853	.58	747	1.95
6500	.771	.93	749	2.08
7000	.690	1.26	752	2.20
7100				2.22 ← FROM GRAPH
	FAILED - BULGING IN BOTTOM THIRD.			

Load on Pan	Dial Rdg.	Strain	Area	σ_1

REMARKS:

SAMPLE STILL APPEARED TOO DRY - WILL INCREASE W/C IN NEXT TEST AND OBSERVE EFFECT ON STRENGTH.

19l.0# USED IN SPECIMEN

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #4
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 6/58

Machine Data:-
Machine No. 1
Multiplication Factor
Wt. Loading Block + Piston (gms.)

Description of Sample: — 3" CRAWFORD GRAVEL — COMPACTED 95 IN #2.

193# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_3)		at not.	0.30					
Length		inches	24.0					
Area		sq. cms.	742					
Volume		c.c.s.	1.595					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	116.1					
G_s= · Volume Soil Solids		γ_{moist}	121.0					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	25566					
Wt. Tare + Soil		"	24640					
Number and weight of Tare		"	2393					
Wt. Soil		"	22247					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	926					
	Moisture content	%	4.21					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1
gms	"	%	cm^2	kg/cm^2	$\sigma_1-\sigma_3$									
0	0.986	0	742	0.34	.03									
500	.983													
1000	.973	0.05	742	.61	0.30									
1500	.962													
2000	.951	.15	743	.88	~~.84~~ 0.57									
2500	.939													
3000	.926	.25	744	1.15	0.84									
3500	.915													
4000	.902	.35	744	1.42	1.11									
4500	.889													
5000	.875	.46	745	1.68	1.37									
5500	.856													
6000	.828	.66	747	1.95	1.64									
6500	.771	.90	749	2.08	1.77									
6700	.711	1.15	751	2.12	1.81									
6900	.622	1.52	754	2.17	1.86									
7100	402	2.43	766	2.21	1.90									
	FAILED — BULGING ABOUT MIDDLE OF SPECIMEN													

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PROJECT
SITE
SAMPLE TEST # 5
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 10/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 Kgm.

Description of Sample: -3" CRAWFORD GRAVEL.
198# MOISTMATL. USED IN SPECIMEN

SPECIMEN DATA

		1	2	3	4	5	6
Specimen Number							
Lateral Pressure (σ_3)	atmos.	0-40					
Length	inches	24.1					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.604					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	118.2					
G_s= · Volume Soil Solids	γ_{moist}	123.4					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	25547					
Wt. Tare + Soil	"	24566					
Number and weight of Tare	"	2393					
Wt. Soil	"	22173					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	981					
	Moisture content %	4.43					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1
gms	"	%	cm^2	Kgm/cm^2
0	0.992	0	742	0.65
400	.991	.004	742	.76
1000	.989	.02	742	.92
2000	.983	.04	742	1.19
3000	.974	.07	742	1.46
4000	.965	.11	743	1.73
5000	.952	.17	744	1.99
6000	.936	.23	744	2.26
6500	.926	.27	744	2.40
7000	.912	.33	744	2.53
7500	.894	.41	745	2.66
8000	.868	.51	746	2.79
8500	.830	.67	748	2.92
9000	.720	1.13	751	3.05
9200	.590	1.67	755	3.09
9400	.442	2.28	759	3.13
9500	.250	3.08	766	3.13
9600	.025	4.02	774	3.13
	† FAILED - BULGING ABOUT MIDDLE			

Load on Pan	Dial Rdg.	Strain	Area	σ_1

Load on Pan	Dial Rdg.	Strain	Area	σ_1

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #6
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 12/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 kgm.

Description of Sample: 3" CRAWFORD GRAVEL.
195.8# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_3)		atmos.	0.86					
Length	inches		24.1					
Area	sq. cms.		742					
Volume	c.c.s.	ft^3	1.605					
Dry Unit Weight	lbs/cu.ft.	γ_{dry}	117.7					
G_s = · Volume Soil Solids		γ_{moist}	122.0					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	29401					
Wt. Tare + Soil		"	28433					
Number and weight of Tare		"	2393					
Wt. Soil		"	26040					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	968					
	Moisture content	%	3.72					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
gms	"	%	cm^2	kgm/cm^2
0	0.993	0	742	0.92
500	.991	.01	742	1.05
1000	.988	.02	742	1.19
1500	.985	.03	742	1.32
2000	.98[illegible]	.05	742	1.46
2500	.977	.07	743	1.59
3000	.973	.09	743	1.73
3500	.967	.11	743	1.86
4000	.962	.13	743	2.00
4500	.958	.15	744	2.13
5000	.953	.17	744	2.26
5500	.948	.19	744	2.40
6000	.942	.21	744	2.53
6500	.935	.24	744	2.67
7000	.926	.28	745	2.80
7500	.917	.32	745	2.93
8000	.906	.36	746	3.07
8500	.894	.41	746	3.20
9000	.879	.47	746	3.33
9500	.860	.55	747	3.46
10000	.833	.66	748	3.59
10500	.797	.81	749	3.72
11000	.749	1.01	750	3.85
11500	.672	1.33	753	3.98

Load on Pan	Dial Rdg.	Strain	Area	σ_1
11700	.[illegible]98	1.65	755	4.02
12000	.[illegible]97	1.98	[illegible]	4.09
12400	.[illegible]00	2.46	[illegible]	4.18
12600	.[illegible]27	[illegible]	[illegible]4	4.22
12700	FAILED - BULGING ABOUT MIDDLE			

Load on Pan	Dial Rdg.	Strain	Area	σ_1

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #7
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 16/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 Kgm.

Description of Sample: 3" CRAWFORD GRAVEL

193.8# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_m) atmos.		0.60					
Length inches		24.0					
Area sq. cms.		742.					
Volume c.c.s.		1.595					
Dry Unit Weight lbs/cu.ft. γ_{dry}		116.5					
G_s= · Volume Soil Solids γ_{moist}		121.5					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end gms.		27605					
Wt. Tare + Soil "		26567					
Number and weight of Tare "		2393					
Wt. Soil "		24174					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	1038					
	Moisture content %	4.29					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
gms	"	%	cm^2	kgm/cm^2	$\sigma_1-\sigma_m$									
0	.986	0.00	742	0.65	0.05									
1000	.987	.04	742	.92	.30									
2000	.977	.08	743	1.19	.57									
3000	.967	.12	743	1.46	.84									
4000	.955	.17	744	1.72	1.10									
5000	.944	.22	744	1.99	1.37									
6000	.932	.27	744	2.26	1.64									
7000	.914	.34	744	2.53	1.91									
8000	.884	.47	746	2.79	2.17									
9000	.827	.70	748	3.06	2.44									
9500	.775	.92	749	3.19	2.57									
10000	.670	1.36	753	3.31	2.69									
10400	.495	2.09	758	3.39	2.77									
10600	.297	2.80	764	3.42	2.80									
	FAILED - BULGING ABOUT LOWER THIRD.													

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SOIL MECHANICS LABORATORY
TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST # 8
LOCATION
HOLE DEPTH
TECHNICIAN DATE

Machine Data:-
Machine No.
Multiplication Factor
Wt. Loading Block + Piston (gms.)

Description of Sample: 3" RAW FOR D GRAVEL
195# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

		1	2	3	4	5	6
Specimen Number							
Lateral Pressure (σ_3)	atmos.	0 92					
Length	inches	4.1					
Area	sq. cms.	742.					
Volume	c.c.s.	1605					
Dry Unit Weight	lbs/cu.ft.	117.2					
G_s = · Volume Soil Solids		121.0					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gm.	29153					
Wt. Tare + Soil	"	28195					
Number and weight of Tare	"	400					
Wt. Soil	"	27792					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water	" 974					
	Moisture content	% 3.78					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
gms	"	%	cm^2	kgm/cm^2	$\sigma_1 - \sigma_3$									
0	0.985	0	742	0.98	0.02									
1000	.984	0.004	742	1.25	.30									
2000	.976	.04	742	1.52	.57									
3000	.968	.07	743	1.79	.84									
4000	.958	.11	743	2.06	1.11									
5000	.949	.15	743	2.33	1.38									
6000	.937	.20	744	2.59	1.64									
7000	.925	.25	744	2.86	1.91									
8000	.911	.31	744	3.13	2.18									
9000	.892	.39	745	3.40	2.45									
10000	.868	.49	746	3.66	2.71									
11000	.827	.66	748	3.92	2.97									
12000	.747	.99	749	4.18	3.23									
13000	.612	1.55	754	4.43	3.48									
13500	.433	2.29	759	4.54	3.59									
14000	.245	3.07	765	4.64	3.69									
14300	.020	4.0	773	4.68	3.73									
	FAILED - BULGING ABOUT MIDDLE													

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SOIL MECHANICS LABORATORY
TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #0,
LOCATION
HOLE DEPTH
TECHNICIAN DATE JUNE 21/58

Machine Data:-
Machine No. 7
Multiplication Factor 200
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
2000 gms / 1350 gms { 200 # CRAWFORD GRAVEL; 10 # H.E. CEMENT; 9 # WATER

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		atmos.	0.30					
Length		inches	24.1					
Area		sq. cms.	742					
Volume		c.c.s.	1.605					
Dry Unit Weight		lbs/cu.ft.	γ_{dry}					
G_s= · Volume Soil Solids			γ_{moist} 129.7					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	28633					
Wt. Tare + Soil		"	27296					
Number and weight of Tare		"	2377					
Wt. Soil		"	24919					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1337					
	Moisture content	%	5.37					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
gms	"	%	cm^2	kgm/cm^2	$\sigma_1-\sigma_3$									
0	0.998	0	742	0.34	.13									
1000	.996													
2000	.993	.02	742	.88	.57									
3000	.989													
4000	.985	.05	743	1.42	1.11									
5000	.980													
6000	.974	.10	743	1.96	1.65									
7000	.967													
8000	.959	.16	744	2.48	2.18									
9000	.951													
10000	.945	.22	744	3.03	2.72									
11000	.938													
12000	.932	.27	744	3.57	3.26									
13000	.927													
14000	.922													
15000	.914	.35	744	4.38	4.07									
16000	.909													
17000	.901	.40	745	4.90	4.59									
18000	.895	.43	745	5.18	4.87									
20000	.877	.50	746	5.70	5.39									
21000	.845	.64	746	5.97	5.66									
22000	- FAILED - COMBINATION OF PLASTIC AND SHEAR FAILURE													

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PROJECT
SITE
SAMPLE TEST #10
LOCATION
HOLE DEPTH
TECHNICIAN DATE JULY/58

Machine Data:-
Machine No. BISHOP
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 2.1 Kgm

Description of Sample:
20 lb # USED { 18 # CRAWFORD GRAVEL / 2 # H.E CEMENT / 8 # WATER

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_m)	gr-cms	0.62					
Length	inches	2.9					
Area	sq. cms.	742					
Volume	c.c.s.	1.59					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	123.1					
G_s= · Volume Soil Solids	γ_{moist}	129.6					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	28735					
Wt. Tare + Soil	"	27418					
Number and weight of Tare	"	2377					
Wt. Soil	"	25041					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	1317					
	Moisture content %	5.25					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	"	%	cm²	Kgm/cm²	$\sigma_1 - \sigma_m$									
0	0.373	0	742	0.50	0.03									
500	.349	.10	743	1.32	.70									
1000	.319	.23	743	2.00	1.38									
1500	.297	.32	744	2.67	3.05									
2000	.281	.39	745	3.33	2.71									
2500	.267	.44	745	4.01	3.39									
3000	.254	.50	746	4.68	4.06									
3500	.243	.54	746	5.41	4.79									
4000	.233	.59	746	6.01	5.35									
4500	.223	.63	747	6.68	6.06									
5000	.214	.67	747	7.34	6.72									
5500	.205	.71	747	8.01	7.39									
6000	.194	.75	748	8.67	8.05									
6500	.185	.79	748	9.34	8.72									
7000	.174	.83	748	10.01	9.39									
7500	.161	.89	749	10.67	10.05									
8000	.134	1.0	749	11.33	10.71									
	FAILED - BULGING ABOUT MIDDLE.													

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PROJECT
SITE
SAMPLE TEST #11
LOCATION
HOLE DEPTH
TECHNICIAN DATE July 3/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 Kgm.

Description of Sample:
200# CRAWFORD GRAVEL.
20 #USED { 10 # H.E. CEMENT
9 # WATER

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		atmos	0.905					
Length		inches	2.8.9					
Area		sq. cms.	742					
Volume		c.c.s. ft3	1.59					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	123.8					
G_s= · Volume Soil Solids		γ_{moist}	130.0					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	30791					
Wt. Tare + Soil		"	29427					
Number and weight of Tare		"	2377					
Wt. Soil		"	27050					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1364					
	Moisture content	%	5.04					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_T	Load on Pan	Dial Rdg.	Strain	Area	σ_T	Load on Pan	Dial Rdg.	Strain	Area	σ_T
K gm	ins	%	cm²	Kgm/cm²	K-gm									
0	0.421	0	742	6.96	0.03									
550	.400	.09	742	1.70	.77									
1050	.372	.20	743	2.38	1.45									
1500	.356	.27	744	2.98	2.05									
2000	.344	.32	744	3.65	2.72									
2500	.334	.36	744	4.32	3.39									
3000	.326	.40	745	4.99	4.06									
3500	.318	.43	745	5.66	4.73									
4000	.311	.46	745	6.33	5.40									
4500	.305	.49	746	7.00	6.07									
5000	.298	.52	746	7.66	6.73									
5500	.291	.55	746	8.34	7.41									
6000	.283	.58	747	9.00	8.07									
6500	.275	.61	747	9.67	8.74									
7000	.266	.65	747	10.33	9.40									
7500	.254	.70	748	11.00	10.07									
8000	.235	.78	749	11.65	10.72									
8500	.190	.97	750	12.20	11.37									
	FAILED - BULGING ABOUT MIDDLE													

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PROJECT
SITE
SAMPLE TEST #12
LOCATION
HOLE DEPTH
TECHNICIAN DATE JULY 4/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm.

Description of Sample:
2½" MOLD: 200# CRAWFORD GRAVEL; 10# CEMENT; 9# WATER

SPECIMEN DATA

		1	2	3	4	5	6
Specimen Number		1					
Lateral Pressure (σ_m)	atmos.	0.93					
Length	inches	24.25					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.615					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	124.9					
G_s = · Volume Soil Solids	γ_{moist}	131.3					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms.	33012					
Wt. Tare + Soil	"	31530					
Number and weight of Tare	"	2377					
Wt. Soil	"	29153					
Before Test: Weight of water							
Before Test: Moisture content							
Before Test: Degree of saturation							
After Test: Weight of water	"	1482					
After Test: Moisture content	%	5.09					
After Test: Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
kgm.	ins	%	cm^2	kgm/cm^2	$\sigma_1 - \sigma_{III}$									
0	0.910	0	742	0.99	.03									
500	.907	.01	742	1.66	.70									
1000	.903	.03	742	2.34	1.38									
1500	.898	.05	742	3.01	2.05									
2000	.892	.07	743	3.68	2.72									
2500	.885	.10	743	4.36	3.40									
3000	.878	.13	743	5.03	4.07									
3500	.871	.16	743	5.70	4.74									
4000	.861	.20	744	6.37	5.41									
4500	.855	.23	744	7.04	6.08									
5000	.847	.26	744	7.71	6.75									
5500	.838	.30	744	8.38	7.42									
6000	.828	.34	744	9.05	8.09									
6500	.819	.38	745	9.72	8.76									
7000	.804	.44	745	10.39	9.43									
7500	.787	.51	746	11.05	10.09									
8000	.770	.58	746	11.72	10.76									
8250	.753	.65	747	12.04	11.08									
8500	.723	.77	748	12.36	11.40									
8700	0.680	.95	749	12.62	11.66									
	FAILED - ONLY SLIGHT BULGING NOTICED.													

REMARKS: Highest density and strength to date.

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PROJECT
SITE
SAMPLE TEST #13
LOCATION
HOLE DEPTH
TECHNICIAN DATE JULY 8/58

Machine Data:-
Machine No. T-C
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 1.1 kgm

Description of Sample: -3" CRAWFORD GRAVEL
206# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos	0.28					
Length		inches	24.1					
Area		sq. cms.	742.					
Volume		c.c.s. ft^3	1.604					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	126.2					
G_s= · Volume Soil Solids		γ_{moist}	128.6					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	29481					
Wt. Tare + Soil		"	28130					
Number and weight of Tare		"	2377					
Wt. Soil		"	25753					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1351					
	Moisture content	%	5.25					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_T	Load on Pan	Dial Rdg.	Strain	Area	σ_T	Load on Pan	Dial Rdg.	Strain	Area	σ_T
Kgm.	ins	%	cm^2	kgm/cm^2	$T_{.5m}$									
0	0.990	0	742	0.31	.03									
100	.989	.01	742	.45	.17									
200	.987	.02	742	.58	.30									
300	.979	.05	742	.72	.44									
400	.971	.08	743	.85	.57									
500	.961	.12	743	.99	.71									
600	.951	.16	744	1.12	.84									
700	.939	.21	744	1.25	.97									
800	.923	.28	744	1.39	1.11									
900	.903	.36	745	1.52	1.24									
1000	.878	.46	746	1.66	1.38									
1100	.833	.65	747	1.79	1.51									
1230	.710	1.16	751	1.95	1.67									
	↖ FAILED - BULGING ABOUT MIDDLE.													

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PROJECT
SITE
SAMPLE TEST #1A
LOCATION
HOLE DEPTH
TECHNICIAN DATE July 9

Machine Data:-
Machine No. 1 C.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 2.1 Kgm.

Description of Sample: 3"
CRAWFORD GRAVEL
199# MOIST MATL. USED IN SPECIMEN

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_3) atmos		~~1.00~~					
Length	inches	24.1					
Area	sq. cms.						
Volume	c.c.s. ft³	1.605					
Dry Unit Weight	lbs/cu.ft. γdry	~~120~~	118.0				
G_s = · Volume Soil Solids	γmoist	~~128.4~~	124.0				
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms.	26504					
Wt. Tare + Soil	"	25318					
Number and weight of Tare	"	2377					
Wt. Soil	"	22941					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	1186					
	Moisture content %	5.17					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1
Kgm.	ins	%	cm²	Kgm/cm²										
0	0.970	0	741	0.00										
200	.965	.02	742	.61										
300	.961	.04	742	.74										
400	.955	.06	743	.88										
500	.949	.09	743	1.01										
600	.942	.12	743	1.15										
700	.934	.15	744	1.28										
800	.928	.18	744	1.42										
900	.920	.21	744	1.55										
1000	.908	.26	744	1.67										
1100	.897	.31	745	1.82										
1200	.879	.38	745	1.95										
1300	.877	.46	746	2.08										
1405	.730	1.0	749	2.22										
	† FAILED - BULGING ABOUT MIDDLE.													

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PROJECT
SITE
SAMPLE TEST #15
LOCATION
HOLE DEPTH
TECHNICIAN DATE JULY 10/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
209.5# USED { 200# CRAWFORD GRAVEL; 10# H.E. CEMENT; 9# Water

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		atmos	0-30					
Length		inches	24.1					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.604					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	124.2					
G_s= · Volume Soil Solids		γ_{moist}	130.5					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	31548					
Wt. Tare + Soil		"	30148					
Number and weight of Tare		"	2367					
Wt. Soil		"	27781					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1400					
	Moisture content	%	5.05					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins.	%	cm^2	Kgm/cm^2										
0	0.994	0	742	0.34										
400	.987	.03	742	.88										
800	.959	.15	744	1.41										
1200	.934	.25	744	1.95										
1600	.915	.33	745	2.49										
2000	.896	.41	745	3.03										
2400	.883	.46	746	3.56										
2800	.868	.52	746	4.10										
3200	.855	.58	746	4.63										
3600	.843	.63	746	5.17										
4000	.831	.68	747	5.70										
4400	.819	.73	747	6.23										
4600	.815	.75	748	6.49										
4900	.803	.79	748	6.90										
5000	.798	.81	748	7.03										
5100	.795	.83	748	7.10										
5200	.789	.85	749	7.28										
5300	.775	.91	748	7.42										
	FAILED - ONLY SLIGHT BULGING													

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PROJECT
SITE
SAMPLE TEST #16
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 3/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
203 #USED { 200# CRAWFORD GRAVEL; 10# CEMENT (H.E.); 7.9# WATER

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_3)		atmos.	0.915					
Length		inches	23.9					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.59					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	122.0					
G_s= · Volume Soil Solids		γ_{moist}	127.8					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	31649					
Wt. Tare + Soil		"	30292					
Number and weight of Tare		"	2372					
Wt. Soil								
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1357					
	Moisture content	%	4.87					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	ins.	%	cm^2	kgm/cm^2	$\sigma_1 - \sigma_m$									
0	0.850	0	742	0.97	0.03									
500	.842	0.03	742	1.64	.70									
1000	.825	.10	743	2.32	1.38									
1500	.808	.18	744	2.98	2.04									
2000	.794	.23	744	3.66	2.72									
2500	.778	.29	744	4.33	3.39									
3000	.763	.36	745	5.00	4.06									
3500	.750	.42	745	5.67	4.73									
4000	.733	.49	746	6.33	5.39									
4500	.717	.56	747	7.00	6.06									
5000	.700	.63	747	7.66	6.72									
5500	.674	.74	748	8.32	7.38									
6000	.628	.93	749	8.99	8.05									
6200	0.474	1.57	754	9.21	8.27									
	- FAILED, BULGING													

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #17
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 5/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
207.5# USED { 200# CRAWFORD GRAVEL; 10# CEMENT (H.E.); 8.4# WATER

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_3)		atmos	0.60					
Length		inches	24.1					
Area		sq. cms.	742					
Volume		c.c.s.	1.604					
Dry Unit Weight		lbs/cu.ft.	122.8					
G_s = · Volume Soil Solids			129.3					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	31397					
Wt. Tare + Soil		"	29912					
Number and weight of Tare		"	2372					
Wt. Soil		"	27540					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1485					
	Moisture content	%	5.39					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	ins.	%	cm²	Kgm/cm²	$\sigma_1 - \sigma_3$									
0	0.803	0	742	0.65	0.03									
500	.799	0.02	742	1.32	.70									
1000	.793	.04	742	2.00	1.38									
1500	.786	.07	743	2.67	2.05									
2000	.778	.10	743	3.34	2.72									
2500	.771	.13	743	4.02	3.40									
3000	.762	.17	744	4.69	4.07									
3250	.757	.19	744	5.02	4.40									
3500	.751	.22	744	5.36	4.74									
3750	.745	.24	744	5.69	5.07									
4000	.739	.27	744	6.03	5.41									
4250	.732	.29	744	6.37	5.75									
4500	.723	.33	745	6.69	6.07									
4750	.712	.38	745	7.03	6.41									
5000	.700	.43	745	7.46	6.84									
5250	.672	.54	746	7.69	7.07									
5470	0.615	0.78	748	7.97	7.35									
	FAILED, BULGING													

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SOIL MECHANICS LABORATORY
TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #18
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 5/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 Kgm

Description of Sample: 200# CRAWFORD GRAVEL
198# USED, 7.5# WATER

SPECIMEN DATA

		1	2	3	4	5	6
Specimen Number							
Lateral Pressure (σ_3)	atmos	0.30					
Length	inches	24.1					
Area	sq. cms.	742					
Volume	c.c.s. ft³	1.604					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	117.5					
G_s = · Volume Soil Solids	γ_{moist}	123.5					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms.	25312					
Wt. Tare + Soil	"	24202					
Number and weight of Tare	"	2396					
Wt. Soil	"	21806					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	1110					
	Moisture content %	5.08					
	Degree of saturation						

Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgms.	ins	%	cm²	Kg/cm²	$\sigma_1-\sigma_3$									
0	0.928	0	742	0.34	0.03									
100	.928	0	742	.47	.16									
200	.925	.01	742	.61	.30									
300	.921	.03	742	.74	.43									
400	.917	.05	742	.88	.57									
500	.912	.07	743	1.01	.70									
600	.907	.09	743	1.15	.84									
700	.902	.11	743	1.28	.97									
800	.896	.13	743	1.42	1.11									
900	.889	.16	744	1.55	1.24									
1000	.882	.19	744	1.68	1.37									
1100	.874	.22	744	1.82	1.51									
1200	.860	.28	744	1.95	1.64									
1300	.842	.36	745	2.08	1.77									
1400	.816	.47	746	2.22	1.91									
1470	.450	1.98	758	2.28	1.97									
	— FAILED, BULGING													

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SOIL MECHANICS LABORATORY
TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #19
LOCATION
HOLE DEPTH
TECHNICIAN DATE Aug 6/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm.

Description of Sample:
204# USED { 200# CRAWFORD GRAVEL / 10# CEMENT (H.E.)

SPECIMEN DATA

		1	2	3	4	5	6
Specimen Number							
Lateral Pressure (σ_m)	atmos.	0.93					
Length	inches	24.1					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.604					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	120.3					
G_s= · Volume Soil Solids	γ_{moist}	127.2					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	29217					
Wt. Tare + Soil	"	27730					
Number and weight of Tare	"	2372					
Wt. Soil	"	25358					
Before Test: Weight of water							
Before Test: Moisture content							
Before Test: Degree of saturation							
After Test: Weight of water	"	1487					
After Test: Moisture content	%	5.86					
After Test: Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	ins.	%	cm^2	kgm/cm^2	$\sigma_1-\sigma_m$									
0	0.918	0	742	0.99	0.03									
1000	.904	.06	743	2.34	1.38									
2000	.889	.12	743	3.68	2.72									
3000	.874	.18	744	5.02	4.06									
4000	.858	.25	744	6.37	5.41									
5000	.843	.31	744	7.71	6.75									
6000	.824	.39	745	9.04	8.08									
7000	.797	.50	746	10.37	9.41									
7350	.747	0.71	748	10.83	9.87									
	- FAILED, BULGING													

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PROJECT
SITE
SAMPLE TEST #20
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 8/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
208# USED { 3.5% QUICKLIME AND 7.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos.	0.30					
Length		inches	24.6					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.638					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	119.8					
G_s = · Volume Soil Solids		γ_{moist}	127.0					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	8524					
Wt. Tare + Soil		"	8090					
Number and weight of Tare		"	828					
Wt. Soil		"	7262					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	434					
	Moisture content	%	5.97					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
kgm	ins.	%	cm^2	kgm/cm^2 $\sigma_1-\sigma_{III}$
0	0.928	0	742	0.34 0.03
200	.922	.02	742	.61 .30
400	.908	.08	743	.88 .57
600	.894	.14	743	1.15 .84
800	.880	.20	744	1.41 1.10
1000	.865	.26	744	1.68 1.37
1200	.850	.32	744	1.95 1.64
1500	.822	.43	745	2.35 2.04
1700	.797	.53	746	2.62 2.31
1900	.768	.65	747	2.88 2.57
2000	.748	.73	748	3.01 2.70
2100	.716	.86	749	3.15 2.84
2190	.570	1.48	754	3.25 2.94
	— FAILED, BULGING			

Load on Pan	Dial Rdg.	Strain	Area	σ_1

Load on Pan	Dial Rdg.	Strain	Area	σ_1

REMARKS:
Sample mixed 3 min.
Tested after molding
(ie no cure)

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #21
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 8/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1.
Wt. Loading Block + Piston (gms.) 21. kgm

Description of Sample: 201# USED { 3.5% QUICKLIME AND 7.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos.	0.60					
Length		inches	23.9					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.59					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	119.4					
G_s= · Volume Soil Solids		γ_{moist}	126.3					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	8997					
Wt. Tare + Soil		"	8544					
Number and weight of Tare		"	802					
Wt. Soil		"	7742					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	453					
	Moisture content	%	5.85					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	ins.	%	cm^2	kgm/cm^2	$\sigma_1-\sigma_m$									
0	0.910	0	742	0.65	0.05									
500	.883	0.11	743	1.32	.70									
750	.869	.17	744	1.66	1.04									
1000	.854	.23	744	1.99	1.37									
1500	.824	.36	745	2.66	2.04									
1750	.805	.44	745	3.00	2.38									
2000	.785	.52	746	3.33	2.71									
2100	.774	.57	747	3.46	2.84									
2200	.762	.62	747	3.59	2.97									
2300	.748	.68	748	3.73	3.11									
2400	.732	.74	748	3.86	3.24									
2500	.716	.81	748	3.99	3.37									
2600	.689	.92	749	4.12	3.50									
2700	.647	1.10	750	4.25	3.63									
2780	.490	1.76	756	4.33	3.71									
	- FAILED, BULGING													

REMARKS:
Sample remixed 3 min
Tested immediately after molding.

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PROJECT
SITE
SAMPLE TEST #22
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 8/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample: 200# USED { 3.5% QUICKLIME AND 7.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos	0.93					
Length		inches	23.8					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.58					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	119.9					
G_s= · Volume Soil Solids		γ_{moist}	126.7					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	8385					
Wt. Tare + Soil		"	7977					
Number and weight of Tare		"	800					
Wt. Soil		"	7177					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	408					
	Moisture content	%	5.69					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
Kgm.	ins.	%	cm^2	kgm/cm^2
0	0.823	0	742	0.99
500	.796	.11	743	1.66
1000	.752	.30	744	2.33
1500	.713	.46	746	3.00
2000	.681	.60	747	3.67
2500	.649	.73	748	4.33
3000	.604	.92	749	5.00
3200	.577	1.04	750	5.36
3400	.542	1.18	751	5.52
3500	.513	1.30	751	5.65
3600	.470	1.49	754	5.77
3700	.385	1.84	756	5.89
3775	.040	3.30	758	5.91
	- FAILED, BULGING			

Load on Pan	Dial Rdg.	Strain	Area	σ_1
σ_3 - σ_m				
0.03				
.70				
1.37				
2.04				
2.71				
3.37				
4.04				
4.30				
4.56				
4.69				
4.81				
4.93				
4.95				

REMARKS: sample tested without benefit of cure.

Load on Pan	Dial Rdg.	Strain	Area	σ_1

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PROJECT
SITE
SAMPLE TEST #23
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 15/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 2/Kgm

Description of Sample:
204# Moist Matl Used { 3.5% QUICKLIME AND 7.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_3)		atmos	0.93					
Length		inches	24.25					
Area		sq. cms.						
Volume		c.c.s. ft^3	1.615					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	119.7					
G_s = · Volume Soil Solids		γ_{moist}	126.4					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	24396					
Wt. Tare + Soil		"	23206					
Number and weight of Tare		"	2396					
Wt. Soil		"	20810					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1190					
	Moisture content	%	5.72					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1
Kgm.	ins	%	cm^2	kgm/cm^2	$\sigma_1 - \sigma_3$									
0	0.902	0	742	0.99	0.03									
1000	.878	0.10	743	2.34	1.38									
2000	.849	.22	744	3.68	2.72									
3000	.814	.36	745	5.02	4.06									
3500	.798	.43	745	5.69	4.73									
4000	.776	.52	746	6.35	5.39									
4500	.741	.66	748	7.01	6.05									
4875	.590	1.29	752	7.48	6.52									
	- FAILED, BULGING													

REMARKS:

Test specimen cured one week at room temperature before test.

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PROJECT
SITE
SAMPLE TEST #24
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 12/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
201.5 # USED { 2.0% QUICKLIME AND 4.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_3) atmos.		0.30					
Length	inches	22.9					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.59					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	120.2					
G_s = · Volume Soil Solids	γ_{moist}	126.8					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	8259					
Wt. Tare + Soil	"	7871					
Number and weight of Tare	"	794					
Wt. Soil	"	7077					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	388					
	Moisture content %	5.49					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins	%	cm^2	Kg/cm^2	$\sigma_1 - \sigma_3$									
0	0.860	0	742	0.34	0.03									
250	.854	.03	742	.68	.37									
500	.849	.09	743	1.01	.70									
700	.828	.13	743	1.28	.97									
800	.822	.16	744	1.42	1.11									
900	.817	.18	744	1.55	1.24									
1000	.812	.20	744	1.68	1.37									
1100	.807	.22	744	1.82	1.51									
1200	.801	.25	744	1.95	1.64									
1300	.795	.27	744	2.09	1.78									
1400	.788	.30	744	2.22	1.91									
1500	.781	.33	744	2.36	2.05									
1600	.775	.36	745	2.49	2.18									
1700	.766	.39	745	2.62	2.31									
1800	.758	.43	745	2.76	2.45									
1900	.746	.48	746	2.89	2.58									
2000	.733	.53	746	3.02	2.71									
2100	.714	.61	747	3.15	2.84									
2200	.684	.74	748	3.28	2.97									
2250	.560	1.26	751	3.33	3.02									
	- FAILED, BULGING													

REMARKS
- Sample was not allowed to cure before test.

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PROJECT
SITE
SAMPLE TEST #25
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 12 1958

Machine Data:-
Machine No. T-O.
Multiplication Factor 1.
Wt. Loading Block + Piston (gms.) 21 Kgm

Description of Sample: 2% QUICKLIME AND 202.5# USED 4% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_m) atmos		0.61					
Length	inches	24.0					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.595					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	120.5					
G_s= · Volume Soil Solids	γ_{moist}	127.0					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	9287					
Wt. Tare + Soil	"	8837					
Number and weight of Tare	"	800					
Wt. Soil	"	8037					
Before Test	Weight of water						
	Moisture content						
	Degree of saturation						
After Test	Weight of water "	450					
	Moisture content η_o	5.61					
	Degree of saturation						

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins.	%	cm^2	Kgm/cm^2	$\sigma_1-\sigma_m$									
0	0.980	0	742	0.66	0.03									
250	.964	.07	743	1.00	.37									
500	.943	.15	743	1.33	.70									
750	.926	.23	744	1.67	1.04									
1000	.909	.30	744	2.00	1.37									
1250	.894	.36	745	2.34	1.71									
1500	.878	.43	745	2.67	2.04									
1750	.861	.50	746	3.01	2.38									
2000	.843	.57	747	3.34	2.71									
2250	.820	.67	748	3.67	3.01									
2500	.784	.82	749	4.00	3.34									
2600	.757	.93	749	4.13	3.50									
2700	.717	1.10	750	4.26	3.63									
2800	.535	1.85	756	4.37	3.24									
- FAILED - BULGING														

REMARKS:
- Sample had no curing period.

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PROJECT
SITE
SAMPLE TEST # Z6
LOCATION
HOLE DEPTH
TECHNICIAN DATE Aug 12/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 2.1 Kgm

Description of Sample:
203# USED { 2% QUICKLIME AND 40% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_3)		atmos.	0.915					
Length		inches	24.0					
Area		sq.cms.	742					
Volume		c.c.s. ft³	1.595					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	121.0					
G_s = · Volume Soil Solids		γ_{moist}	127.3					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	8806					
Wt. Tare + Soil		"	8410					
Number and weight of Tare		"	802					
Wt. Soil		"	7608					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	396					
	Moisture content	%	5.21					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins.	%	cm²	kgm/cm²	$\sigma_1 - \sigma_3$									
0	0.949	0	742	0.97	0.03									
500	.933	.07	743	1.64	.70									
750	.923	.11	743	1.98	1.04									
1000	.914	.15	743	2.32	1.38									
1250	.905	.18	744	2.65	1.71									
1500	.896	.22	744	2.99	2.05									
1750	.888	.25	744	3.32	2.38									
2000	.878	.30	744	3.66	2.72									
2250	.866	.35	745	3.96	3.02									
2500	.854	.40	745	4.33	3.39									
2700	.842	.45	745	4.60	3.66									
2900	.827	.51	746	4.86	3.92									
3100	.809	.58	747	5.11	4.17									
3300	.775	.72	748	5.39	4.45									
3500	.724	.94	749	5.64	4.70									
3600	.676	1.14	751	5.76	4.82									
3700	.597	1.47	754	5.88	4.94									
3775	.200	3.12	766	5.90	4.96									
	- FAILED - BULGING													

REMARKS:
- Test specimen was not allowed to cure before test.

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PROJECT
SITE
SAMPLE TEST #27
LOCATION
HOLE DEPTH
TECHNICIAN DATE Aug 19/58

Machine Data:-
Machine No.
Multiplication Factor
Wt. Loading Block + Piston (gms.)

Description of Sample:
202# Moist Mate. used { 2.0% QUICKLIME AND 4.0% FLYASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		atmos	0.90					
Length		inches	23.75					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.58					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	121.7					
G_s= · Volume Soil Solids		γ_{moist}	127.9					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	27492					
Wt. Tare + Soil		"	26277					
Number and weight of Tare		"	2422					
Wt. Soil		"	23855					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1215					
	Moisture content	%	5.09					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg	Strain	Area	σ_1
Kgms	ins.	η_0	cm^2	Kg/cm^2	$\sigma_1 - \sigma_m$									
0	0.902	0	742	0.96	0.03									
500	.885	0.07	743	1.63	.70									
1000	.864	.16	744	2.30	1.37									
1500	.847	.23	744	2.98	2.05									
2000	.833	.29	744	3.65	2.72									
2500	.819	.35	745	4.32	3.39									
3000	.809	.39	745	4.99	4.06									
3500	.785	.49	746	5.65	4.72									
3150	.775	.53	746	5.99	5.06									
4000	.758	.61	747	6.32	5.39									
4200	.739	.69	748	6.58	5.65									
4300	.723	.75	748	6.71	5.78									
4400	.696	.87	749	6.84	5.91									
4490	.532	1.56	754	6.92	5.99									
	- FAILED, BULGING													

REMARKS:
Test specimen cured seven days at room temperature (~22°C) and at molding water content.

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SOIL MECHANICS LABORATORY

TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST # 28
LOCATION
HOLE DEPTH
TECHNICIAN DATE SEPT. 9/58

Machine Data:-
Machine No. T.O
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 Kgm

Description of Sample:
199 # MOIST MATL. USED { 3.5% QUICKLIME AND 7.0% FLY ASH BY WEIGHT OF CRAWFORD GRAVEL

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)		atmos.	0.30					
Length		inches	23.9					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.59					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	119.3					
G_s= · Volume Soil Solids		γ_{moist}	125.2					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	22653					
Wt. Tare + Soil		"	21692					
Number and weight of Tare		"	2422					
Wt. Soil		"	19270					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	961					
	Moisture content	%	4.99					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins	%	cm^2	Kgm/cm^2	$\sigma_1 - \sigma_m$									
0	0.894	0	742	0.34	.03									
500	.879	.06	743	1.01	.70									
750	.871	.10	743	1.35	1.04									
1000	.860	.14	743	1.69	1.38									
1200	.849	.19	744	1.95	1.64									
1400	.838	.23	744	2.22	1.91									
1600	.825	.29	744	2.49	2.18									
1800	.811	.35	745	2.76	2.45									
2000	.794	.42	745	3.03	2.72									
2200	.771	.51	746	3.29	2.98									
2400	.725	.71	748	3.55	3.24									
2500	.697	.82	749	3.68	3.37									
2600	.657	.99	750	3.81	3.50									
2650	.573	1.34	753	3.86	3.55									

- FAILED, BULGING ABOUT CENTER OF SPECIMEN

REMARKS:

Sample mixed 3 min.
Specimen cured 7 days. at room temperature and molding water content.

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #29
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 29/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 Kgms

Description of Sample:
205.0# OF MOIST 2.0% H.E. CEMENT
BY WEIGHT OF CRAWFORD GRAVEL
MIXTURE USED IN SPECIMEN

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos.	0.30					
Length		inches	23.92					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.593					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	122.3					
G_s= · Volume Soil Solids		γ_{moist}	128.8					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms.	27711					
Wt. Tare + Soil		"	26418					
Number and weight of Tare		"	2422					
Wt. Soil		"	23996					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1293					
	Moisture content	%	5.39					
	Degree of saturation							

Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm.	ins.	%	cm^2	kg/cm^2	$\sigma_1 - \sigma_m$									
0	0.988	0	742	0.34	0.03									
250	.983	0.02	742	.68	.37									
500	.973	.06	743	1.01	.70									
750	.966	.09	743	1.35	1.04									
1000	.959	.12	743	1.69	1.38									
1250	.952	.15	743	2.02	1.71									
1500	.945	.18	744	2.36	2.05									
1750	.937	.21	744	2.69	2.38									
2000	.929	.25	744	3.03	2.72									
2250	.921	.28	744	3.36	3.05									
2500	.907	.34	744	3.70	3.39									
2750	.889	.41	745	4.03	3.72									
2900	.871	.49	746	4.23	3.92	REMARKS:								
3000	.855	.56	747	4.36	4.05	Sample mixed 3 min								
3100	.832	.65	748	4.49	4.18	Specimen cured 24 hr.								
3200	.780	.87	749	4.62	4.31	before test at								
3210	.720	1.12	750	4.62	4.31	room temp. and								
						at con 50%								
	- FAILED, BULGING													
	ABOUT CENTRAL													
	PORTION OF													
	SPECIMEN													

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #30
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 30/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
205.5# OF MOIST 2.0% H.E. CEMENT
BY WEIGHT OF CRAWFORD GRAVEL
MIXTURE USED IN SPECIMEN

SPECIMEN DATA

Specimen Number		1	2	3	4	5	6
Lateral Pressure (σ_m)	atmos	0.65					
Length	inches	24.37					
Area	sq. cms.	742					
Volume	c.c.s. ft^3	1.62					
Dry Unit Weight	lbs/cu.ft. γ_{dry}	120.9					
G_s= · Volume Soil Solids	γ_{moist}	126.9					
Wt. Tare + Soil + Water at start							
Wt. Tare + Soil + Water at end	gms	23472					
Wt. Tare + Soil	"	22467					
Number and weight of Tare	"	2422					
Wt. Soil	"	20045					
Before Test: Weight of water							
Before Test: Moisture content							
Before Test: Degree of saturation							
After Test: Weight of water	"	1005					
After Test: Moisture content	%	5.03					
After Test: Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins	%	cm^2	kg/cm^2	$\sigma_1-\sigma_m$									
0	0.953	0	742	0.65	0.00									
500	.935	.07	743	1.32	.70									
1000	.903	.21	744	1.99	1.37									
1500	.875	.32	744	2.67	2.05									
2000	.849	.43	745	3.33	2.71									
2250	.836	.48	746	3.67	3.05									
2500	.823	.53	746	4.00	3.38									
2750	.810	.59	747	4.33	3.71									
3000	.794	.65	748	4.66	4.04									
3250	.775	.73	748	4.99	4.37									
3500	.750	.83	748	5.31	4.69									
3600	.735	.89	749	5.46	4.84									
3700	.718	.96	750	5.59	4.97									
3800	.682	1.11	750	5.71	5.09									
3820	.642	1.28	751	5.74	5.12									

FAILED BY BULGING ABOUT CENTER OF SPECIMEN

REMARKS:
Sample mixed 3 min. Test specimen cured 24 hr at room temp. and at molding water content.

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST #31
LOCATION
HOLE DEPTH
TECHNICIAN DATE AUG 31/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 Kgm

Description of Sample:
203 # OF MOIST 2% H.E. CEMENT BY WEIGHT OF CRAWFORD GRAVEL MIXTURE USED IN SPECIMEN

SPECIMEN DATA

			1	2	3	4	5	6
Specimen Number								
Lateral Pressure (σ_m)		atmos	0.90					
Length		inches	24.13					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.604					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	120.8					
G_s= · Volume Soil Solids		γ_{moist}	126.6					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	29781					
Wt. Tare + Soil		"	28510					
Number and weight of Tare		"	2422					
Wt. Soil		"	26088					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1271					
	Moisture content	%	4.87					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1	Load on Pan	Dial Rdg.	Strain	Area	σ_1
Kgm	ins	%	cm^2	kg/cm^2	$\sigma_1 - \sigma_m$									
0	0.905	0	742	0.96	0.03									
500	.882	0.10	743	1.63	.70									
1000	.856	.20	744	2.30	1.37									
1500	.834	.30	744	2.98	2.05									
2000	.812	.39	745	3.65	2.72									
2500	.791	.47	746	4.31	3.38									
3000	.773	.55	747	4.98	4.05									
3250	.763	.59	747	5.31	4.38									
3500	.751	.64	747	5.65	4.72									
3750	.738	.69	748	5.98	5.05									
4000	.721	.76	748	6.31	5.38									
4200	.708	.82	748	6.58	5.65									
4400	.686	.91	749	6.84	5.91									
4500	.674	.96	750	6.96	6.03									
4600	.658	1.02	750	7.10	6.17									
4700	.638	1.11	750	7.23	6.30									
4800	.601	1.26	751	7.35	6.42									
4900	.490	1.72	755	7.45	6.52									
4920	.372	2.21	759	7.45	6.52									

FAILED - BULGING ABOUT MIDDLE THIRD

REMARKS:
Sample mixed 4 min.
Specimen cured 24 hr. at molding water content and room temperature.

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TRI-AXIAL COMPRESSION

PROJECT
SITE
SAMPLE TEST # 32
LOCATION
HOLE DEPTH
TECHNICIAN DATE SEPT. 2/58

Machine Data:-
Machine No. T.O.
Multiplication Factor 1
Wt. Loading Block + Piston (gms.) 21 kgm

Description of Sample:
209.5# OF MOIST 5% H.E. CEMENT BY WEIGHT OF CRAWFORD GRAVEL MIXTURE USED IN SPECIMEN

SPECIMEN DATA

Specimen Number			1	2	3	4	5	6
Lateral Pressure (σ_m)			UNCONFINED					
Length		inches	24.25					
Area		sq. cms.	742					
Volume		c.c.s. ft^3	1.615					
Dry Unit Weight		lbs/cu.ft. γ_{dry}	123.3					
G_s= · Volume Soil Solids		γ_{moist}	129.8					
Wt. Tare + Soil + Water at start								
Wt. Tare + Soil + Water at end		gms	30004					
Wt. Tare + Soil		"	29603					
Number and weight of Tare		"	2388					
Wt. Soil		"	26215					
Before Test	Weight of water							
	Moisture content							
	Degree of saturation							
After Test	Weight of water	"	1401					
	Moisture content	%	5.34					
	Degree of saturation							

Load on Pan	Dial Rdg	Strain	Area	σ_1
Kgm	ins	%	cm^2	kg/cm^2
0	0.992	0	742	0.03
500	.985	.03	742	.70
1000	.975	.07	743	1.37
1500	.963	.12	743	2.05
1700	.959	.14	743	2.32
1900	.954	.16	744	2.58
2100	.949	.18	744	2.85
2300	.944	.20	744	3.12
2500	.939	.22	744	3.39
2700	.934	.24	744	3.66
2900	.927	.27	744	3.93
3100	.918	.31	744	4.19
3200	.912	.33	744	4.33
3300	.902	.37	745	4.46
3370	.863	.53	746	4.55

FAILED - BULGING ABOUT MIDDLE OF SPECIMEN.

Load on Pan	Dial Rdg.	Strain	Area	σ_1
$\sigma_1 - \sigma_m$				
←				

REMARKS:
Sample mixed 3 min.
Specimen cured 24 hr at room temperature and molding moisture content.

Load on Pan	Dial Rdg.	Strain	Area	σ_1

B29778